

Oil Palm Industry Economic Journal

O P I E J

CONTENTS

- 19 Smallholders' and Plantation Workers' Perceptions on the Quality of Work Rendered in Estates of Two Oil Palm Companies in Cameroon: Disharmony Between Policy and Practice?
Tarh Betrand Mbah; Ntaebenu Taku Julie and Pascal Tabi Tabot

- 34 Bridging the Capacity Gap: A TAPIC Framework Analysis of Carbon Pricing Instruments for Malaysian Palm Oil Sector
Hisham Hussain; Sufian Jusoh and Laziana Ahmad

- 47 Factors Shaping Job Satisfaction Among Local Machine Operators in Malaysia's Mechanised Oil Palm Estates
Siti Zuwairiah Abdullah and Selvakkumar K N Vaiappuri

- 60 Malaysian Palm Oil Sector During the Israel and United States-Iran Conflict (February–April 2026): A Content Analysis Approach of the Media Framing
Amirul Afif Muhamat; Adibah Alawiah Osman; Mohamad Nizam Jaafar; Sri Rezeki and Norzifah Abdul Karim



MPOB Press

Malaysian Palm Oil Board

6, Persiaran Institusi, Bandar Baru Bangi

43000 Kajang, Selangor, Malaysia

Tel: +603-8769 4400 | Fax: +603-8925 9446

eISSN 2948-3557



9 772948 355009

Available online <http://opiej.mpob.gov.my/>

Oil Palm Industry
**Economic
Journal**
O P I E J

Volume 26 (2)/September 2026



MPOB Press
Malaysian Palm Oil Board
6, Persiaran Institusi, Bandar Baru Bangi
43000 Kajang, Selangor, Malaysia
Tel: +603-8769 4400 | Fax: +603-8925 9446

OIL PALM INDUSTRY ECONOMIC JOURNAL
Vol. 26 (2)/ SEPTEMBER 2026

EDITORIAL BOARD

(1 January 2026 – 31 December 2028)

Editor-In-Chief

Dr. Mohd Hefni Rusli

Malaysian Palm Oil Board, Malaysia

Associate Editors

Prof. Dato' Dr Roslan Abd. Shukor

Universiti Kebangsaan Malaysia, Malaysia

Prof. Dr. Mondher Bellalah

EPM – Ecole Polytechnique Méditerranéenne;
MIT Polytech, Tunisia

Prof. Dr. Shaufique Fahmi Ahmad Sidique

Universiti Putra Malaysia, Malaysia

Prof. Dr. Amirul Afif Muhamat

Universiti Teknologi MARA (UiTM), Malaysia

Prof. Dr. Pietro Puganini

Temple University of Philadelphia, USA

Prof. Dr. Sanjar Goyipnazarov

Tashkent State University, Uzbekistan

Prof. Dr. Giovanni Barone-Adesi

University of Lugano, Switzerland

Dr. Mauricio Mosquera-Montoya

Centro de Investigación en Palma de Aceite
(CENIPALMA), Colombia

Prof. Dr. Prem Chhetri

RMIT University, Melbourne, Australia

Dr. Afolabi Fatai Agboola

Foremost Development Services Limited, Nigeria

PUBLICATION COMMITTEE

CHAIRPERSON

Dr. Mohd Hefni Rusli

SECRETARY

Dr. Anita Taib

MANAGING EDITOR

Dr. Laziana Ahmad

PRODUCTION EDITOR

Mohamad Syaiful Mohd Yusof

COMMITTEE MEMBERS

Dr. Aki@Zaki Aman

Johari Minal

Mohd. Saufi Awang

Dr. Sivaruby Kanagaratnam

Dr. Rajinder Singh

Dr. Meilina Ong Abdullah

Dr. Zafarizal Aldrin Azizul Hasan

Nasrin Abu Bakar

Nor Hayati Mohammad

Azizah Lockman

Oil Palm Industry Economic Journal (OPIEJ) is published twice a year, i.e. March and September by the Malaysian Palm Oil Board (MPOB).

© Malaysian Palm Oil Board, 2026

All rights reserved. No part of this publication may be reproduced in any form or by any means without the written permission of the Malaysian Palm Oil Board. Views of writers expressed in this publication are not necessarily those of MPOB.

MPOB welcomes contributions and comments from all individuals and organisations. Their inclusion is however, the prerogative of the Director-General of MPOB.

Contributions and comments should be addressed to:

Director-General

Malaysian Palm Oil Board

6, Persiaran Institusi, Bandar Baru Bangi,

43000 Kajang, Selangor, Malaysia.

SMALLHOLDERS' AND PLANTATION WORKERS' PERCEPTIONS ON THE QUALITY OF WORK RENDERED IN ESTATES OF TWO OIL PALM COMPANIES IN CAMEROON: DISHARMONY BETWEEN POLICY AND PRACTICE?

TARH BETRAND MBAH¹; NTAEBENU TAKU JULIE¹ and PASCAL TABI TABOT^{1*}

ABSTRACT

Oil palm plantations in Cameroon display significant yield gaps, limiting their potential in alleviating poverty in the country. Understanding the causes of these yield gaps requires multifaceted studies. This study assessed perceptions of smallholders and plantation workers of PAMOL Plantations PLC. (PAMOL) and the Cameroon Development Corporation (CDC) on the state of output on their plantations. A total of 277 plantation workers and smallholders were sampled through a purposive stratified approach and data were analysed in SPSS version 21. A majority (66.17%) of smallholders were not satisfied with nursery output due to seedling mortality (33.90%), stunted growth (23.40%) and low survival rate (42.70%). Perception of weeding operations was poor (74.44%) due to farms being weedy (46.80%), lack of footpaths (34.10%) and presence of recalcitrant weeds (19.00%). Respondents agreed that there is a death of seedlings in the nursery ($\chi^2 = 6.033$, $p = 0.014$). Triangulation with Quality Standards suggests a disagreement between the perceptions of nursery output, pruning and harvesting and the recommended standards on the one hand, and alignment in weeding operations and the quality standards on the other. Better field monitoring, enforcement of quality benchmarks, and studies towards the revision of the standards for weeding operations are recommended.

Keywords: agronomic operations, oil palm plantations, quality standards, seedling nurseries, triangulation.

Received: 7 February 2026; **Accepted:** 17 July 2026; **Published online:** 26 August 2026.

INTRODUCTION

Oil palm is a major cash crop in Tropical Africa, parts of Asia and Latin America. From its fronds to the roots, it has extensive uses. The two most economically important products derived from oil palm are palm oil (PO) from the fruits and palm kernel oil (PKO) from the nuts left over after or as a by-product of PO milling, depending on the setup of the extraction process (Corley & Tinker, 2016; Ndam et al., 2024). In tropical countries such

as Cameroon, where agriculture is the backbone of the economy and the climate favours oil palm production, oil palm is often a major contributor to gross domestic product (GDP). According to the Food and Agriculture Organization (FAO) of the United Nations (2017), Cameroon has a huge domestic and sub-regional market for crude palm oil (CPO). However, the country remains a net importer of CPO, importing 130,564 t in 2025, as reported in the Cameroon Export Bulletin (MINEPAT Bulletin, 2026). Data from the U.S. Department of Agriculture (USDA) Foreign Agriculture Service shows that in 2025, about 100,000 ha of oil palm were grown by small and medium holders with an additional 3,500 ha regeneration programme initiated in the same year, and 900,000 ha were owned and

¹ Department of Agriculture,
Higher Technical Teachers' Training College, Kumba,
University of Buea, Buea, Cameroon.

* Corresponding author e-mail: ttabot@yahoo.com

exploited by larger corporations in Cameroon (USDA, 2026). The land area under cultivation with oil palm is not sufficient to meet domestic oil needs.

Currently, industrial oil palm plantations and PO processing in Cameroon are managed by five large companies, among which are two national companies with the status of parastatals, namely the Cameroon Development Corporation (CDC) and PAMOL Plantations PLC. (PAMOL) (Hakizumwami, 2014). PAMOL and CDC are the government's flagships for PO production and related goods (Kimengsi & Lambi, 2015). With the intention to boost national production, these parastatals also oversee to various degrees, a growing number of smallholders who are affiliated to the smallholder scheme of the Ministry of Agriculture and Rural Development in Cameroon. Yet PO production in the country continues to lag behind domestic demand.

Cameroon still imports about 21% of the PO used domestically (FAO, 2019). This situation could be improved if the factors responsible for inefficiencies during production are identified and addressed. The quantity and quality of output within planted areas of these plantations is dependent on several factors which fall under the three main dimensions of production; the planted land area, the available capital and labour issues such as the efficiency of the workforce, the quality standards recommended by the plantations and how effective these are adhered to by the workers, and managerial aspects (Henindar & Sari, 2020; Masitah et al., 2023). Therefore, to improve yields without expanding land area under cultivation, it requires unravelling the dynamics between these interrelated factors.

In Cameroon, capital isn't really a challenge for parastatals and cannot really be a limitation to production. This is because the Boards of Directors are at liberty to vote their budgets based on projected output targets. Therefore, the one dimension requiring closer scrutiny is the human dimension; aspects related to labour and management. This is the dimension that determines the profitability of land and capital, and is also most influenced by the prevailing socio-political atmosphere (Chiarella et al., 2023). In addition, the plantation workforce acts as the first line of advocacy and advertisement, and so perceptions of the workers on aspects of production are a first step in diagnosing challenges to production.

The purpose of this study was to assess perceptions of smallholders and permanent plantation workers (field workers) of the PAMOL and CDC on the state of output on their plantations at various stages of production, with a view to identifying avenues for improvement. The results are significant in informing management

on the state of implementation of the plantation quality standards, as well as other areas that require revision of the said standards for better output.

MATERIALS AND METHODS

Study Site

The study was conducted in Ndian and Fako Divisions of the South West Region of Cameroon. These divisions host the main oil palm plantations of PAMOL and CDC, respectively. In Ndian Division, the survey covered Ekondo Titi Sub Division in the main towns of Ekondo Titi, Ngolo and Bekora. In Fako Division, the survey covered the major towns of Idenau, Moliwe and Bakingili. *Figure 1* shows a map of the different study sites.

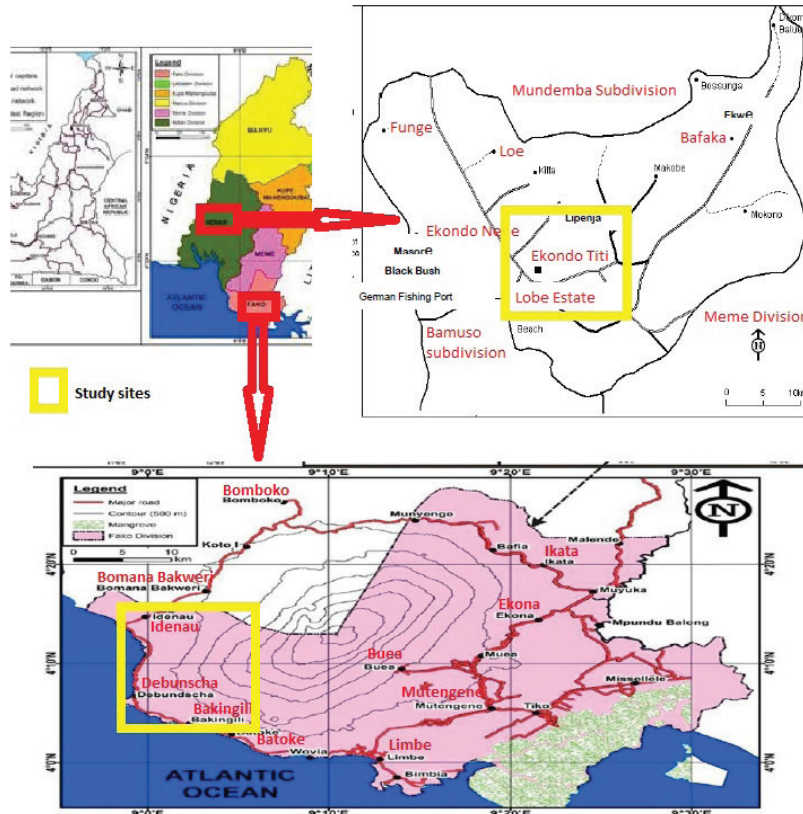
Target Population and Sample Size

This study targeted two sets of respondents: Firstly, workers in two commercial plantations (CDC and PAMOL) and secondly, smallholders at Ekondo Titi in Ndian Division, and Idenau in Fako Division of the South West Region of Cameroon, who are affiliated to the smallholder schemes of the CDC and PAMOL. These smallholders are registered with the Divisional Delegations of the Ministry of Agriculture and Rural Development (MINADER) and are regularly audited.

The sample size for the study was determined using the Krejcie and Morgan (1970) table. The smallholder farmers' population was obtained from the Divisional Delegations of MINADER in Ndian and Fako Divisions. There are 308 registered smallholder farmers in Ndian Division in the palm sector. In Fako Division, there are 94 registered smallholders in the CDC smallholder scheme. This gives a total population of 402 smallholders. With respect to the plantation workers, in the palm sector of PAMOL, there are 318 workers and 456 workers in the palm sector of CDC in Fako Division. This gives a total of 774 plantation workers. The expected and effective sample sizes are presented in *Table 1*. Due to the ongoing socio-political crisis in the region, only 139 respondents could be accessed for the smallholder farmers' survey and 138 for the plantation workers survey, giving a total effective sample size of 277.

Reconnaissance Survey

A reconnaissance survey was carried out to identify potential study sites. During this phase, the different towns were visited to assess the level of activities in the plantations and the presence or



Note: Adapted from Kimengsi and Lambi (2015), and Obale (2020).

Figure 1. Map showing the different study sites in Fako and Ndian Divisions of the South West Region of Cameroon.

TABLE 1. TARGET SMALLHOLDER AND PLANTATION WORKERS IN IDENAU AND EKONDO TITI

Survey group	Population	Expected sample	Effective sample
Smallholders	402	196	139
Plantation workers	774	260	138
Total	1176	291	277

Note: Adapted from Krejcie and Morgan (1970).

absence of workers due to the current socio-political crisis. Discussions were held with key respondents, some of whom were selected as field guides for the study.

Sampling Design

The sampling approach was purposive, targeting permanent palm plantation workers and smallholders affiliated to the CDC and PAMOL. Other farmers or residents were not considered. At the level of questionnaire administration and data analysis, the study was stratified, with smallholders constituting the first stratum and plantation workers the second stratum. However, at the level of the plantations studied, the data were not stratified, meaning for all practical purposes the fields of the CDC and PAMOL were treated as one. This is because they have the same supervisory Ministry

in Cameroon, and operate under similar quality guidelines. They are also in proximity and within the same agro-ecological zone.

Questionnaire Design and Administration

Structured questionnaires were used for primary data collection. The questionnaire was self-designed and consisted of five main sections, namely demographics, nursery, weeding, pruning and harvesting operations. For each technical section, information was collected on the type of operation, how it is executed, how it is supposed to be executed, and respondents' assessment of the work done. The typical problems and challenges faced by the respondents in executing the different tasks were also covered in the questionnaire. For the type of activities carried out, the respondents were expected to choose from a list of items arranged

in a binary manner. For questions on perceptions, the list of possible items was arranged in the form of a Likert scale. The questionnaire was tested for validity by pilot administration to 25 respondents. This phase sought to identify whether the responses received were consistent with expected responses. The responses received were entered into SPSS and subjected to reliability analyses where Cronbach's alpha was computed for multi-item scales and Kuder-Richardson 20 for dichotomous items in the questionnaire. *Table 2* shows the results of the reliability assessment. Areas with low consistency were typically those subject to binary coding. Overall, the instrument was deemed sufficiently valid for the study.

The questionnaires were then administered in person by the researchers and field assistants. The questionnaires sought to collect data on perceptions of respondents on key palm plantation operations such as nursery practices, weeding, pruning, harvesting and plantation operations, as well as perceptions on the best management approaches on maintenance and their effects on yields. The

perceived intervals for weeding (interline weeding, ring weeding, path and key way weeding and post weeding) were obtained from questionnaires to both smallholders and plantation workers. Secondary data were collected on management practices at the nursery, weeding, pruning and harvesting operations at the production stages from the PAMOL Quality Standards.

Demographic Characteristics of the Sample

Table 3 shows the demographic characteristics of the sample. The majority of the smallholders were male (71.2%), and most of them were between the ages of 29–38 years (45.3%), followed by 39–48 years (26.6%), and typically married (66.9%), with significant household sizes (48.2% had 6–10 children, followed by 43.9% of households with 1–5 children). With respect to plantation workers, a majority were male (83.3%), with the most frequent workforce between the ages of 29–38 years (58.7%), and most (69.6%) were married, with a household size of 1–5 being the most frequent.

TABLE 2. RELIABILITY ASSESSMENT OF THE QUESTIONNAIRE

Parameter	No. of items	Test statistic	Conclusion
Cronbach's alpha			
Demographic characteristics	4	0.720	Acceptable consistency
Technical characteristics	4	0.095	Poor consistency
Plantation tasks	5	0.883	Strong consistency
Kuder-Richardson 20			
Nursery problems	5	–5.765	Inconclusive
Weeding operations	4	0.752	Acceptable consistency
Weeding problems	3	0.854	Strong consistency
Pruning problems	3	0.711	Acceptable consistency
Harvesting problems	5	0.695	Acceptable consistency

TABLE 3. DEMOGRAPHIC CHARACTERISTICS OF THE SMALLHOLDERS AND PLANTATION WORKERS

Item	Smallholders		Plantation workers	
	Frequency	Percentage	Frequency	Percentage
Gender				
Male	99	71.2	115	83.3
Female	40	28.8	23	16.7
Total	139	100.0	138	100.0
Age group				
18–28	31	22.3	29	21.0
29–38	63	45.3	81	58.7
39–48	37	26.6	25	18.1
>48	8	5.8	3	2.2
Total	139	100.0	138	100.0
Marital status				
Single	46	33.1	42	30.4
Married	93	66.9	96	69.6
Total	139	100.0	138	100.0
Household size				
1–5	61	43.9	67	48.9
6–10	67	48.2	36	26.3
11–15	10	7.2	32	23.4
>15	1	0.7	2	1.5
Total	139	100.0	137	100.0

Palm Quality Standards for Triangulation

The PAMOL maintains an archive of reference documents on palm plantation operations, and the following were consulted: Harvesting record books, maintenance record books, yield record books, nursery development manual, which we collectively refer to in this work as the PAMOL Quality Standards. An official extract of these standards was also obtained from PAMOL in response to a request from the research team.

Analysis of Survey Data

Data from the surveys were entered into SPSS version 21 and coded. Four questionnaires were rejected from the plantation workers' survey due to lack of completeness, giving a net sample of 138 questionnaires. In the course of the study, it was realised that both the CDC and PAMOL, being state parastatals, apply similar quality standards and since they are within the same agro-ecological zone, there was no stratification with respect to company. Thus, the analysis and interpretation were done considering the sample to be drawn from the same population. Where more than one response was possible for a question, the multiple response approach was used.

Each survey data set was independently subjected to inferential and descriptive statistical analysis. Chi-Square (χ^2) test of association at $\alpha = 0.05$

was used to compare responses to similar queries from both the smallholders and the plantation workers survey. Triangulation was then done between the smallholders' and plantation workers' responses to the PAMOL Quality Standards to determine the level of convergence or divergence of survey responses with official recommendations on plantation management.

Cross-Referencing with PAMOL Field Data

Following data analysis, this study requested PAMOL official opinions backed by their internal data on the parameters assessed, including nursery output, the state of weeding, the state of pruning, and the state of harvesting. It was not possible to access field data from the CDC, so inferences were made using the PAMOL data and the Manual of Oil Palm Operations Quality Standards as references.

RESULTS AND DISCUSSION

Economic Characteristics of the Smallholders

The economic characteristics of the sample are presented in *Table 4*. A majority of the smallholders were from the private sector (68.3%), and most of the respondents were farmers by profession (96.4%). For farmers, the majority owned plantations (66.2%)

TABLE 4. ECONOMIC CHARACTERISTICS OF RESPONDENTS OF THE SMALLHOLDERS AND PLANTATION WORKERS

Smallholders			Plantation workers		
Parameter	Frequency	Percentage	Parameter	Frequency	Percentage
Employment status			Sector of employment		
Self employed	26	18.7	Smallholders	24	17.4
Private sector	95	68.3	Plantation worker	100	72.5
Public sector	18	12.9	Both	14	10.1
Total	139	100.0	Total	138	100.0
Main profession			Parastatal employed in		
Farming	134	96.4	PAMOL	107	77.5
Trading	3	2.2	CDC	31	22.5
Technical works	2	1.4	Total	138	100.0
Total	139	100.0			
For farmers, scale of farming			Job description		
Plantation	90	66.2	Field worker	104	78.2
Subsistence	46	33.8	Manager	20	15.0
Total	136	100.0	Both	9	6.8
			Total	133	100.0
Work experience			Work experience		
0-5 years	27	20.3	1-5	8	6.1
6-10 years	77	57.9	6-10	57	43.2
11-15 years	20	15.0	11-15	61	46.2
16-20 years	9	6.8	>15	6	4.5
Total	133	100.0	Total	132	100.0

and most of them worked in the palm sector (95.7%). A majority of the smallholders have been in the sector between 6–10 years (57.9%). With respect to plantation workers, most are field workers (78.2%), with a majority (89.4%) having work experience of 5–15 years in the sector.

Tasks Performed by Respondents in the Palm Sector

The main tasks smallholders perform on their farms are nursery operations, weeding, harvesting, pruning, and milling, with pruning (26.1%) accounting for the single highest daily task and least being milling (14.8%) (Table 5). Similarly, the single most frequent task for plantation workers was weeding (24.0%), with the least being nursery work (9.7%). Some workers perform two or more operations depending on the necessity of work requirements at any given time and their level of skill. Other important tasks include pruning (17.8%) and harvesting (18.1%) (Table 5).

Smallholders' Perceptions of Key Performance Indicators in the Plantations Under Study

Figure 2 presents the level of satisfaction of smallholders with key performance indicators in the plantations. A majority (66.2%) were not satisfied with nursery output. Respondents' reasons for

dissatisfaction with nursery performance included seed mortality (33.9%), stunted growth (23.4%) and low survival rate (42.7%) (Table 6). Many of the respondents (74.44%) were not satisfied with the state of weeding in the plantations, due to weedy farms (46.8%), lack of footpaths (34.1%) and presence of recalcitrant weeds (19.0%). Similarly, a majority of the smallholders (59.09%) were not satisfied with the quality of pruning. Respondents' reasons for perceiving that pruning in the plantations is poor included poor harvesting practices, poor canopy management and poor crown cleaning.

Regarding harvesting, a majority (60.9%) of respondents were not satisfied with the quality of the harvest. Some of the reasons for dissatisfaction are dirty crowns, unweeded rings/paths and poor saprophytes removal. Similarly, 66.67% of smallholders were not satisfied with the state of milling output due to perceived low extraction rate (<20.0% of PO extraction), obsolete machines and outdated technology still being used.

Plantation Workers' Perceptions of Performance Indicators in the Plantations

Very few workers (10%) feel that nursery output is good. A majority (73.30%) rate the nursery output as average (Figure 3). Figure 3 also shows respondents' perception of the intervals of

TABLE 5. TASKS CARRIED OUT BY SMALLHOLDERS AND PLANTATION WORKERS IN THE ESTATES STUDIED

Parameters ^a	Responses		Percentage of cases
	N	Percentage	
Smallholders			
Nursery	34	16.7	25.4
Weeding	42	20.7	31.3
Harvesting	44	21.7	32.8
Pruning	53	26.1	39.6
Milling	30	14.8	22.4
Total	203	100.0	151.5
Plantation workers			
Nursery work	35	9.7	25.5
Weeding	86	24.0	62.8
Harvesting	65	18.1	47.4
Pruning	64	17.8	46.7
Mulching	36	10.0	26.3
Fertiliser application	36	10.0	26.3
Agricides application	37	10.3	27.0
Total	359	100.0	262.0

Note: ^a - dichotomy group tabulated at value 1; N - number of responses.

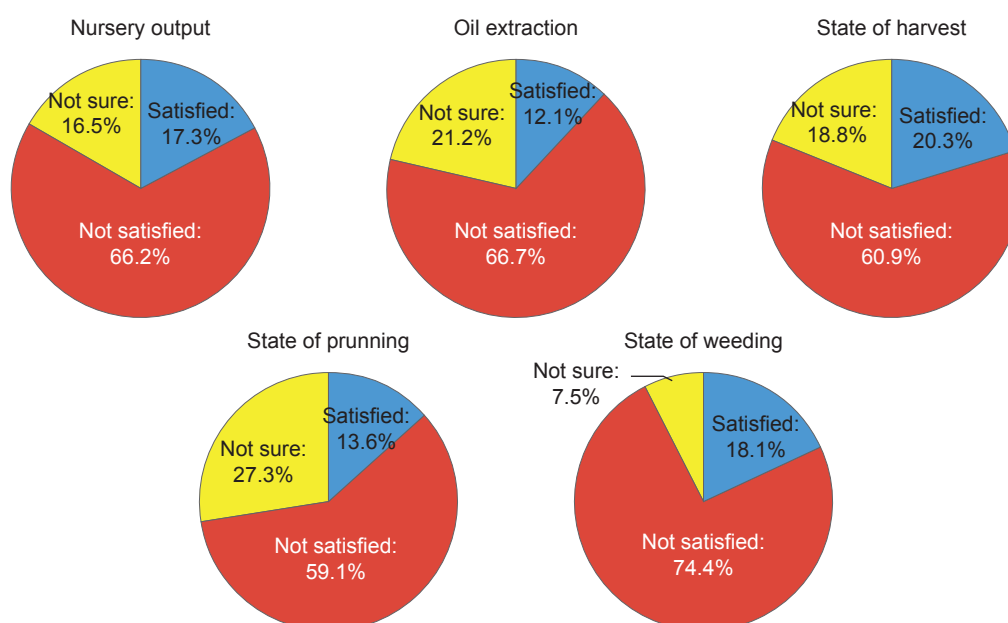


Figure 2. Smallholders' perceptions on the state of nursery, weeding, pruning, harvest and oil extraction operations in the plantations.

TABLE 6. SMALLHOLDERS' PERCEPTION OF REASONS FOR DISSATISFACTION WITH NURSERY OUTPUT AND WEEDING PERFORMANCE

Parameters ^a	Responses		Percentage of cases
	N	Percentage	
Perception of nursery output			
Seeds mortality	42	33.9	42.4
Stunted growth	29	23.4	29.3
Low survival	53	42.7	53.5
Total	124	100.0	125.3
Perception of the state of weeding			
Weedy farm	59	46.8	56.7
No footpath	43	34.1	41.3
Recalcitrant weeds	24	19.0	23.1
Total	126	100.0	121.2

Note: ^a - dichotomy group tabulated at value 1; N - number of responses.

weeding. The majority (74.74%) of the workers sampled indicated that the weeding interval is 6 months, with a few indicating that the weeding is done once a year (10.53%).

Plantation Workers' Perceptions of Key Performance Indicators in the Plantations Under Study

Plantation workers' perceptions of reasons for poor nursery performance are presented in Table 7. Death of seedlings at the level of the nursery had the highest percentage (38.3%). Other reasons advanced for poor nursery performance include low survival rate (30.4%) and stunted growth (16.5%). Most of the workers (43.9%) indicated that

the poor state of the fruit post (43.9%) was the main indicator of poor weeding. With respect to pruning, a majority of the respondents (75.0%) indicated that there is poor frond management, while some respondents feel that saprophytes are also poorly managed (19.4%). There were also perceptions on problems associated with harvesting, such as poor road network (32.7%) and poorly weeded rings and paths (27.2%).

Plantation Workers' Technical Perspectives for Weeding and Harvesting to Ensure Better Yield

Table 8 shows respondents' perspectives on the options and duration of weeding and harvesting for better yield. A majority (54.2%)

proposed that interline weeding should be intensified. The best recommended interval for weeding to achieve better yield was six months (76.6%) for palms above eight years, in which a canopy is already formed to suppress weeds naturally. Many harvesters (43.8%) reported that presently, the harvesting interval is 14 days, while

12.5% reported that it is seven days and 29.75% that it is above 28 days. On proposals for a better harvesting interval, a majority (66.7%) proposed that harvesting should be done every 14 days, while the lowest proposal was seven days (4.8%). These proposals are for mature palms above eight years old.

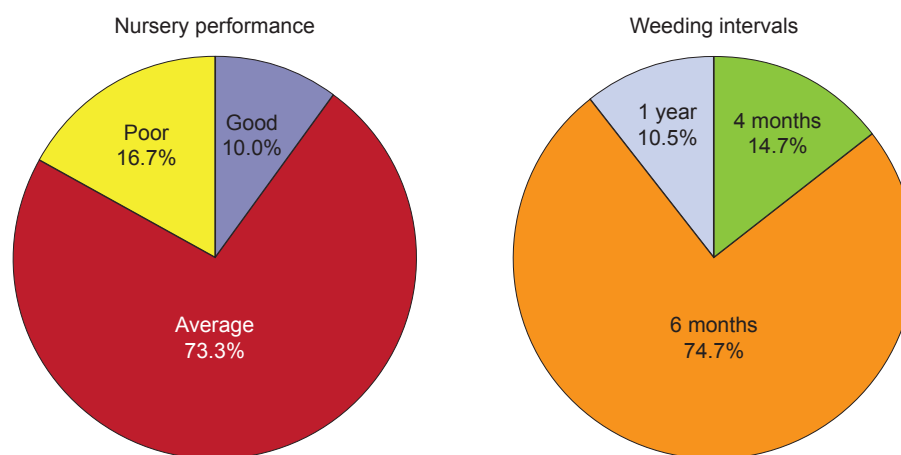


Figure 3. Plantation workers' perceptions on the state of nursery and weeding operations in the plantations.

TABLE 7. PLANTATION WORKERS' PERCEPTIONS ON THE REASONS FOR POOR PERFORMANCE IN THE PLANTATIONS

Parameter ^a	Responses		Percentage of cases
	N	Percentage	
Reasons for poor nursery performance			
Seeds mortality	44	38.3	75.9
Stunted growth	19	16.5	32.8
Pests and diseases	17	14.8	29.3
Low survival rate	35	30.4	60.3
Total	115	100.0	198.3
Problems associated with weeding			
Rings state	15	22.7	28.8
Path and keyway state	22	33.3	42.3
Fruit post state	29	43.9	55.8
Total	66	100.0	126.9
Problems associated with pruning			
Fronds problems	54	75.0	85.7
Saprophytes state	14	19.4	22.2
Crown state	4	5.6	6.3
Total	72	100.0	114.3
Problems associated with harvesting			
Low cycle harvesting	20	13.6	31.3
High cycle harvesting	32	21.8	50.0
Poor ring and path weeding	40	27.2	62.5
Poor crown cleaning	7	4.8	10.9
Poor road network	48	32.7	75.0
Total	147	100.0	229.7

Note: ^a - dichotomy group tabulated at value 1; N - number of responses.

TABLE 8. PLANTATION WORKERS' PERSPECTIVES FOR BETTER WEEDING AND HARVEST OPERATIONS

Weeding		Harvesting	
Parameter	Percentage	Parameter	Percentage
Proposed weeding options for better yield		Actual harvesting interval	
Ring weeding duration	28.9	7 days	12.5
Interline weeding	54.2	14 days	43.8
Post weeding	16.9	28 days	12.5
Total	100.0	Above 28 days	31.3
		Total	100.0
Proposed weeding interval for better yield		Proposed harvesting options for better yield	
3 months	17.2	7 days	4.8
6 months	76.6	14 days	66.7
1 year	6.3	Above 28 days	28.6
Total	100.0	Total	100.0

Official Quality Standards for Oil Palm Plantation Operations in PAMOL Palm Estates

Excerpts of the quality standards recommended for PAMOL palm estates are presented in Table 9. Recommended practices in the nursery include bag filling, mulching and fertilisation. Weeding in the field is age-dependent, likewise pruning. These activities are to be done every three months for palms less than eight years old and every six months for palms older than eight years old. Other quality standards recommended are presented in Table 9.

Association Between Responses of Smallholders and Plantation Workers with Respect to Nursery and Weeding Performance

Results of χ^2 test of association between responses of the smallholders and those of the plantation workers on nursery and weeding performance are presented in Table 10. With respect to nursery performance, there were strong associations between the responses. Smallholders and plantation workers agreed that there is death of seedlings in the nursery ($\chi^2 = 6.033$, $p = 0.014$), and this reflects in the relationship between smallholders' perception of low seedling survival with plantation workers' perception of seedling death ($\chi^2 = 6.964$, $p = 0.008$). Other relevant associations are presented in Table 10. With respect to weeding performance, no associations were found between responses of plantation workers and those of smallholders ($p > 0.05$ in all cases).

Triangulation of Results from the Survey

Results of triangulation of responses on nursery, weeding, pruning and harvesting performance from the smallholders and the plantation workers

with PAMOL Manual of Oil Palm Operations Quality Standards are presented in Figure 4. There is a general agreement between the plantation workers and smallholders that nursery output is low and not consistent with PAMOL Manual of Oil Palm Operations Quality Standards. Similarly, the results of triangulation of responses on weeding operations show that there is general agreement between the plantation workers and the smallholders that the state of weeding is poor. This is consistent with the PAMOL Manual of Oil Palm Operations Quality Standards that recommend prolonged durations for interline weeding (3–6 months) and paths, rings and fruit post-weeding (3 months).

Smallholders and plantation workers also agree that the state of pruning is poor. This is consistent with the PAMOL Manual of Oil Palm Operations Quality Standards, which recommends an eight-monthly cycle for pruning, as well as with findings from Marcelino & Diaz (2016), who recommended that pruning should be done once or twice a year depending on the appearance of desiccated fronds, dead male flowers and the appearance of epiphytes and saprophytes on the palm crowns. With respect to the state of harvesting, results of triangulation show a general agreement between the workers and the smallholders on the state of harvesting, and their perceptions are not consistent with the PAMOL Manual of Oil Palm Operations Quality Standards on harvesting.

Actual Fresh Fruit Bunch (FFB) and Oil Yield from PAMOL

The perceptions of smallholders and plantation workers on yield and other aspects of production need to be evaluated in line with actual yield data, which PAMOL generously provided. This study focused on the years since 2008, to better appreciate

TABLE 9. PAMOL QUALITY STANDARDS FOR NURSERY AND FIELD OPERATIONS

Stage of plantation	Operation	Timing	Method	Other considerations
Nursery	Bag filling	2 months before planting	Good quality fertile soil, either <i>in situ</i> or transported in. All dirt removed.	Soil mixed with 2 g rock phosphate for mini-bags and 50 g for large polybags.
	Mulching	At pre-nursery, before planting of seeds	Decomposed bunch stalks, dried grass, wood shavings used. Top placement around seed after loosening the soil 7–10 cm from top of bag.	Mulch is spread and replenished as and when necessary.
	Fertilisation	Weekly at the rate of 40 mL/seedling; Every 2 weeks, starting from the 4-leaf stage, with doses increasing by 10 mL for every additional leaf	28 g ammonium phosphate + 28 g muriate of potash + 14 g kieserite or 14 g ammonium sulphate + 28 g muriate of potash + 14 g kieserite, dissolved in 10 L of water.	Solid fertiliser commences at 9 leaf stage and comprises 15 g ammonium sulphate, 15 g muriate of potash and 15 g kieserite.
	Weeding	Every 3 months until all noxious/woody weeds are suppressed, then every 6 months if woody or noxious weeds return	At the beginning and end of the rainy season or shortly before applying fertiliser or shortly before the peak season or when need for weeding is observed; cover crop should be allowed to remain at the height of approximately 45–60 cm and beaten down with the back of a machete. All other growth should be cut to a height of 15–20 cm. Tree trunks cleaned of saprophytes and epiphytes up to 1.5 m from the ground level.	
	Paths and rings	Weeded every 2–3 months; Whenever weeds are observed above ankle height	Weeding done at ground level; If possible, pull out woody weeds with large roots. If they cannot be pulled out, dig out the stumps with a chisel or spade. Paths weeded 0.5–0.75 m wide, rings weeded 1.5 m radius.	Done at the beginning and end of the dry period or shortly before the peak season.
Semi-mature and mature	Pruning	Once a year, at an 8-month cycle	For palms <4 years old, only dead fronds are removed; For older palms, all desiccated fronds are removed, all dead male flowers, epiphytes and saprophytes on the crown are removed	For palms <8 years old, only 2–3 subtending fronds are left to support the fruit bunch. For palms ≥8 years, 1–2 subtending fronds are left.
	Harvesting	High Crop Period: 7–10 days for palms <8 years old. 10–12 days for palms ≥8 years old. Low Crop Period: 10–12 days for palms <8 years old. 12–14 days for palms ≥8 years old.	Only ripe bunches with ≥3 shed fruits are harvested. Loose fruits trapped in pockets are removed. Unripe, premature, overripe or under-ripe bunches are not harvested.	All harvested fruit bunches and loose fruits are collected and deposited at the crop post, and must reach the factory within 24 hr.
Mature	Milling	Once harvested FFB reaches mill plant capacity	Uses both automatic and semi-automatic milling plants	Extraction rate = 22%

Note: Adapted from PAMOL Manual of Oil Palm Operations Quality Standards.

TABLE 10. RELATIONSHIP BETWEEN RESPONSES OF SMALLHOLDERS AND PLANTATION WORKERS WITH RESPECT TO NURSERY AND WEEDING PERFORMANCE

Smallholders' responses	Plantation workers' responses	χ^2	p-value	Conclusion
Nursery performance				
Death of seedlings	Death of seedlings	6.033	0.014*	Strong association
Death of seedlings	Stunted growth	4.209	0.040	Strong association
Death of seedlings	Low survival	4.209	0.040	Strong association
Stunted growth	Death of seedlings	4.325	0.038	Strong association
Low survival	Death of seedlings	6.964	0.008	Strong association
Low survival	Pests and diseases	13.882	0.000	Strong association
Weeding performance				
Weedy farm	Rings state	0.256	0.613	No association
Weedy farm	Paths and keyways state	2.282	0.131	No association
Weedy farm	Fruit post state	1.683	0.431	No association

Note: Pearson χ^2 tests conducted at $\alpha = 0.05$. Associations exist where $p < 0.05$.

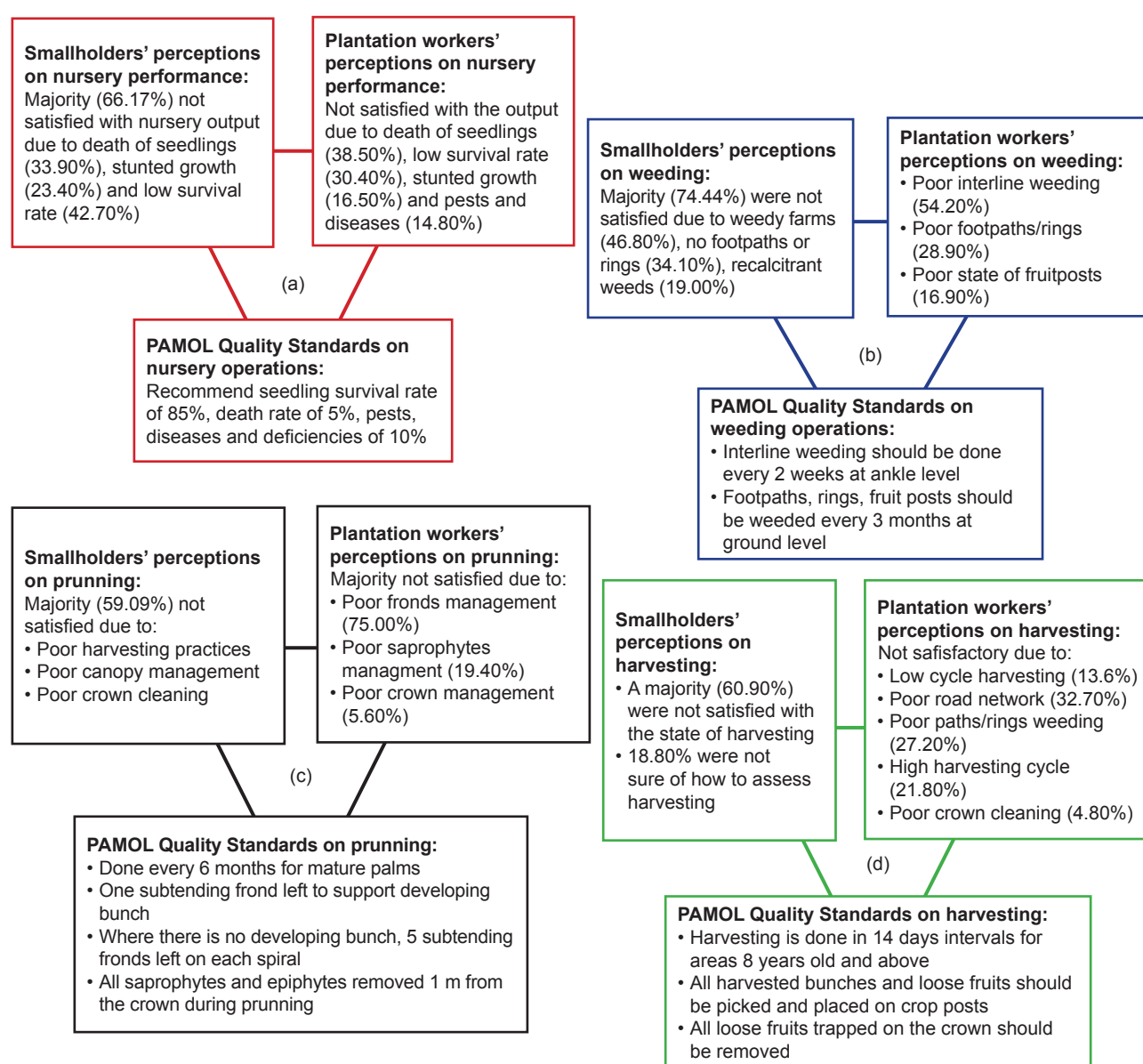


Figure 4. Triangulation of results from the survey on (a) nursery, (b) weeding, (c) pruning and (d) harvesting performances with the PAMOL Manual of Oil Palm Operations Quality Standards.

output in the plantations. *Figure 5* presents the FFB, oil and kernel output from the PAMOL estates. The results are split for two periods, namely 2008 to 2017, which marks a stable period in production, and 2018 to 2023, which is the period during which a violent sociopolitical crisis has been ravaging the region, with the PAMOL operations zone in Ndian Division as a hotspot.

During the first period, PAMOL estates' FFB output represented a declining trend, with 71,999 t of FFB harvested in 2008 compared to 51,599 t in 2017. During the same period, FFB harvested from smallholdings affiliated to PAMOL increased from 3,872 to 27,598 t, resulting in an overall increase in FFB production to a peak in 2017 (79,197 t), just before the crisis intensified. Correspondingly, PO output exhibits a declining trend up to 2012, stabilising at 15,443 t in 2017. In 2019, total FFB yield declined to 2,418 t, with a gradual increase to 20,482 t in 2023, which is still below pre-crisis levels. Smallholders (21.8%) and plantation workers (50.7%) with experience of 11 years and above have a clear idea of the socio-political dynamics during this period, as well as variations in yield.

Perceptions of workers in plantations in particular, and farmers in general, are an essential first step in diagnosing the level of success in that plantations' operations. This is because field workers have firsthand knowledge of what obtains in the field and can give a descriptive appraisal of practices that are poorly implemented (Mdiya et al., 2024). This

study assessed perceptions of plantation workers and smallholders on the state of field operations in plantations of two parastatals in Cameroon with the aim of assessing the state of field operations. With respect to nursery operations, both smallholders and plantation workers reported that nursery performance is poor. PAMOL Manual of Oil Palm Operations Quality Standards for nursery operations recommends a seedling survival rate of 85% as a minimum benchmark. In this case, the workers' perceptions suggest that this benchmark is not met, mainly due to high seedling mortality.

Several factors are responsible for palm seedling performance in the nursery, including poor soil and bag filling, poor irrigation and fertilisation, pests, diseases and weeds (Wijayanti et al., 2025) and deciphering which class of factors is responsible remains complex yet important. According to the PAMOL expert opinion, nursery output was indeed at about 73%–75%, and they explained that this was due to poor irrigation and diseases. This indicates that the Management is already aware of the problem and its causes, but perhaps faces challenges in addressing this.

The state of weeding is reported to be poor, and this seems to be consistent with the quality standards, which recommend three-month intervals for paths, rings and fruit post-weeding. However, PAMOL management indicated that this poor state of weeding was mainly due to a lack of labour to effectively implement the quality standards.

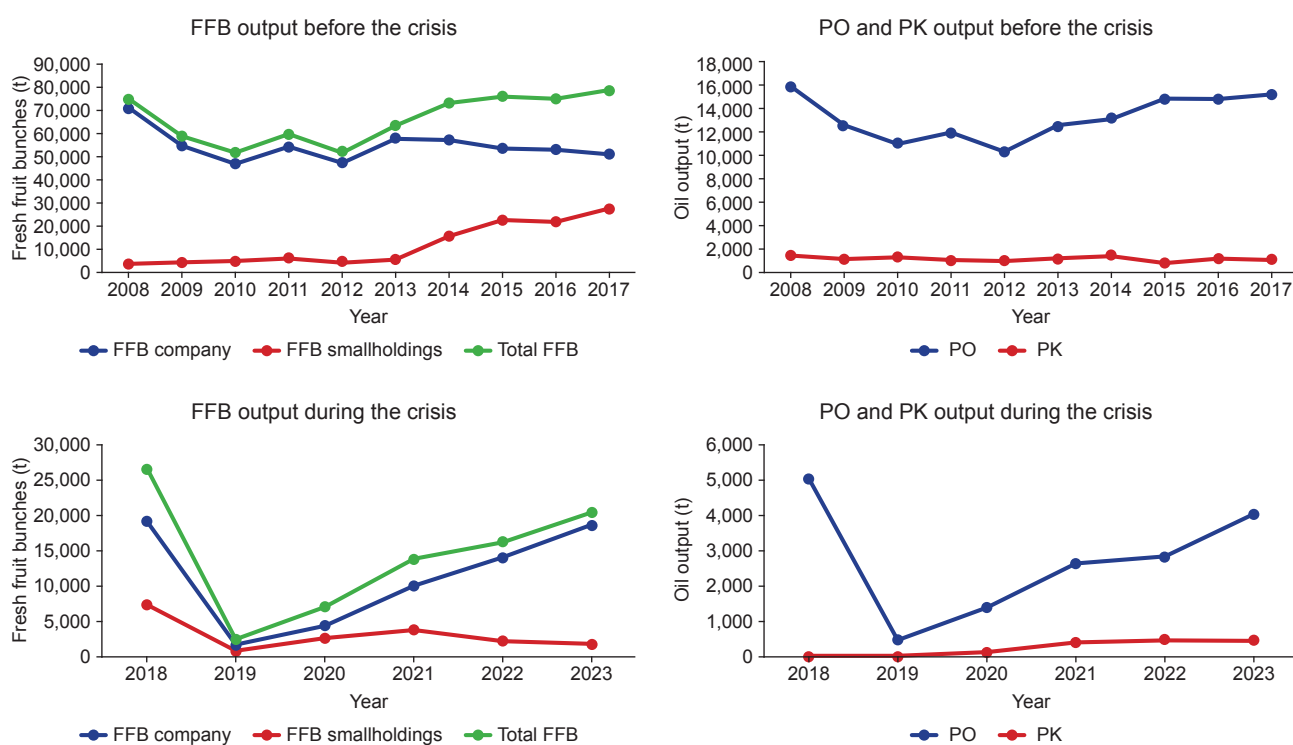


Figure 5. Actual output of fresh fruit bunch (FFB), palm oil (PO) and palm kernel (PK) from PAMOL Estates and Affiliated Smallholders for the period 2008 to 2023.

Notwithstanding, it is essential in this regard to examine the standards approved for weeding within the Cameroon context. In tropical countries like Cameroon with high rainfall and humidity and a prolonged rainy season, regeneration of weeds is fast and growth rates of weeds are very high. Concurrently, rains would act as dispersal agents for weed seeds, further increasing the weed pressure. This is consistent with findings by Singh et al. (2022) who conducted a meta-analysis of several publications and found that weed growth is significantly promoted under water-available conditions, and suppressed under water deficit conditions. With this in mind, it becomes obvious that weeding intervals of three months for paths, rings and fruit posts would be too long in the months from April to September in this part of Cameroon where rainfall ranges between 2,200–3,000 mm/year, and up to 10,000 mm/year in Debunsha, the wettest place on Earth. This suggests a need to revisit the quality standards that regulate weeding in the plantations.

Another key operation in oil palm plantations is pruning. Pruning consists of selective removal of fronds from the stem and crown of the oil palm. In PAMOL and the CDC, pruning is to be done every eight months. During pruning, allow one subtending frond to support a developing fruit bunch and five subtending fronds in each spiral where there is no bunch. It is also recommended to remove epiphytes and saprophytes. Perceptions of respondents indicate dissatisfaction with the state of pruning, due to poor fronds and saprophytes management. If this perception reflects the actual field situation, it would signal potential challenges that could account for yield gaps in FFB production. Rosenfeld (2009) has reported several health benefits of pruning oil palms, including nutrient and water re-allocation, nitrogen and potassium increase, and an increase in FFB size. However, if the pruning is too intensive, yield decreases might result, as well as increased disease susceptibility and structural integrity of the crown might be compromised.

In field operations, a compromise that balances the needs for a healthy and clean palm with the needs of a structurally sound and high-yielding palm should be ideal. According to PAMOL Management, the state of frond removal is within recommended standards, but the general state of pruning hygiene was assessed at 75%, because in reality this is done annually (not within guidelines) due to scarcity of labour, and often coinciding with harvesting. Addo et al. (2023) showed that progressive pruning (the practice of pruning the palm at the same time as harvest) significantly reduced the incidence of the oil palm leaf miner *Coelaenomenodera lameensis* while simultaneously increasing FFB yield. These works point to the

importance of pruning in a palm plantation, and the need for management to address the shortfall in pruners, as this process has a direct implication on yield.

Pruning is sometimes done in tandem with harvesting, which Addo et al. (2023) call progressive pruning. In the plantations of the CDC and PAMOL, harvesting is expected to be done every two weeks for palms above eight years old, with all FFBs and loose fruits collected and placed at the crop post and all loose fruits trapped on the palms are removed. This is standard practice, yet perceptions of plantation workers and smallholders indicate that this process is unsatisfactory, due to poor road network, poor state of paths and rings, poor crown cleaning and a high harvesting interval. Poorly weeded plantations would complicate other downstream operations, including harvesting, and it is not uncommon to find abandoned fruits at the base of the palms, especially in weedy areas where the weeds complicate evacuation of produce. It is well documented that weedy farms negatively impact harvesting of oil palms by disturbing access to fruit trees and hindering collection of loose fruits (Chungait, 2010).

Indeed, internal data from PAMOL shows fluctuating and declining yield in FFBs between 2008 and 2017. This is the period before the socio-political crisis and so these fluctuations reflect yield loss due to conditions intrinsic to the plantation management. All the factors studied, from weeding to harvesting, have the potential to influence yields and contribute to the yield gaps observed in the data. The fluctuations could also be due to replacement of ageing plantations, but this was not reported in our data. The sharp decline in yield of FFBs and PO during the period 2018 to 2023 captures the impact of the armed conflict that commenced in 2017 in the production areas. This displaced the workforce and prevented those present from working, for fear of attacks, as has been reported for cereal production in Burkina Faso under terrorist attacks (Kafando & Sakurai, 2024). Similarly, in the same study (Kafando & Sakurai, 2024), production of perennial crops like cocoa and coffee increased. This has been the trend in Cameroon for privately owned perennial plantation crop farms as well, even within the conflict zones. However, the parastatals are seen as state-owned and therefore a legitimate target for non-state armed groups, and the consequence is declining output due in part to a lack of labour.

From our findings, therefore, two key assumptions can be made on the general negative perceptions: 1) either the quality standards are not being adhered to in the field or 2) the quality standards require revision in some aspects. This requires attention for the perceived yield gap in

the oil palm sector to be reduced. Field workers, overseers and management have to work in harmony and with strict reference to the quality standards manual, so that recommendations therein are matched with application in the field. Secondly, there is a need for studies to test aspects of the quality standards, such as the weeding intervals and the level/height of weeding, so that identified weaknesses can be improved through a revision of the standards. These results are significant, as they can be exploited immediately for improvement in field operations.

CONCLUSION

Our findings show a divergence between respondents' perceptions on nursery output, and a convergence on weeding, pruning and harvesting with the existing quality standards of PAMOL in Cameroon. Taken together, the results indicate general underperformance in field operations in the palm plantation sector in the two parastatals studied, and this can be extrapolated to palm plantations nationwide, since these two parastatals serve as a benchmark for the entire industry in the country. Stricter supervision of field operations and application of quality control guidelines is recommended, as well as further studies aimed at revising aspects of the said guidelines.

ACKNOWLEDGEMENT

The authors thank all the respondents who participated in this study. The management of PAMOL provided data and feedback to strengthen and validate findings, and the authors appreciate this. This research was funded by private funds in addition to the Research Modernization Allowance granted to Professors Pascal Tabi Tabot and Ntaebenu Taku Julie.

REFERENCES

- Addo, I., Ackah, E., Awonnea, S. A., Ofori, K. B., Zutah, V. T., Oduro, G. S., Donkor, E. F., & Santo, K. G. (2023). Impact of progressive pruning on leaf miner (*Coelaenomenodera lameensis*) incidence and the yield of oil palm (*Elaeis guineensis*). *American Journal of Plant Sciences*, 14(4), 377–389. <https://doi.org/10.4236/ajps.2023.143025>
- Chiarella, C., Meyfroidt, P., Abeygunawardane, D., & Conforti, P. (2023). Balancing the trade-offs between land productivity, labor productivity and labor intensity. *Ambio*, 52(10), 1618–1634. <https://doi.org/10.1007/s13280-023-01887-4>
- Chungait, F. (2010). Weed and cover crop management in oil palm. *The Planter*, 86(1017), 857–871.
- Corley, R. H. V., & Tinker, P. B. (2016). The products of the oil palm and their extraction. In R. H. V. Corley & P. B. Tinker (Eds.), *The oil palm* (5th ed., pp. 460–482). John Wiley & Sons. <https://doi.org/10.1002/9781118953297.ch15>
- Food and Agriculture Organization of the United Nations. (2017). *FAOSTAT statistics database*.
- Food and Agriculture Organization of the United Nations. (2019). *Statistics of global palm oil production*. <https://www.fao.org/faostat/en/#data/QCL>
- Hakizumwami, E. (2014). *Baseline study on models for smallholder development with regard to palm oil production in Cameroon*. Proforest. <https://www.proforest.net/fileadmin/uploads/proforest/Documents/Publications/sharp-baseline-study-cameroon.pdf>
- Henindar, D., & Sari, D. W. (2020). Output of Indonesia crude palm oil (CPO) industry: A review. *International Journal of Management*, 11(6), 2011–2022. <https://doi.org/10.34218/IJM.11.6.2020.186>
- Kafando, W. A., & Sakurai, T. (2024). Armed conflicts and household food insecurity: Effects and mechanisms. *Agricultural Economics*, 55(2), 313–328. <https://doi.org/10.1111/agec.12814>
- Kimengsi, J., & Lambi, C. M. (2015). PAMOL Plantations PLC: Prelude to a looming population problem in Ekondo-Titi Sub-Division, South West Region of Cameroon. *Journal of Sustainable Development in Africa*, 17(3), 79–94.
- Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, 30(3), 607–610. <https://doi.org/10.1177/001316447003000308>
- Marcelino, J. P., & Diaz, E. V. (2016). Frond pruning enhanced the growth and yield of eight years old oil palm (*Elaeis guineensis* Jacq.). *Annals of Tropical Research*, 38(2), 96–105.
- Masitah, T. H., Setiawan, M., Indiasuti, R., & Wardhana, A. (2023). Determinants of the palm oil industry productivity in Indonesia. *Cogent Economics & Finance*, 11(1), 2154002. <https://doi.org/10.1080/23322039.2022.2154002>

- Mdiya, L., Aliber, M., Mdoda, L., Van Niekerk, J., Swanepoel, J., & Ngarava, S. (2024). Empowering resilience: The impact of Farmer Field Schools on smallholder livestock farmers' climate change perceptions in Raymond Local Municipality. *Sustainability*, 16(20), 8784. <https://doi.org/10.3390/su16208784>
- MINEPAT Bulletin (2026). *Report on the competitiveness of Cameroon's Economy*. <https://www.minepat.gov.cm>
- Ndam, L., Asongwe, G. A., Nkongho, R., Mbene, K., Tellen, V., Ndi, E., Ma, J., Tening, A., & Fujino, T. (2024). Smallholder palm oil production sector in African countries: State of the art, practices, constraints, and opportunities in Littoral and Centre regions of Cameroon. *African Journal of Agricultural Research*, 20(3), 251–271. <https://doi.org/10.5897/AJAR2023.16516>
- Obale, C.E. (2020). Restructuring of the Cameroon Development Corporation, challenges and coping strategies of plantation workers in Fako Division, South West Region, Cameroon. *International Journal of Research in Geography* 6(2), 7–19. <https://doi.org/10.20431/2454-8685.0602002>
- Rosenfeld, E. (2009). Effects of pruning on the health of palms. *Arboriculture & Urban Forestry*, 35(6), 294–299. <https://doi.org/10.48044/jauf.2009.044>
- Singh, M., Kukal, M. S., Irmak, S., & Jhala, A. J. (2022). Water use characteristics of weeds: A global review, best practices, and future directions. *Frontiers in Plant Science*, 12, 794090. <https://doi.org/10.3389/fpls.2021.794090>
- U.S. Department of Agriculture. (2026). *Production – Palm oil*. USDA Foreign Agricultural Service. <https://www.fas.usda.gov/data/production/42230000>
- Wijayanti, E., Maribun, S. N. S., Mardiyanti, P. H., Rahman, A., Raudha, A. T., Noer, Z., & Aziz, R. (2025). Occurrence of leaf spot disease on oil palm seedlings in Simalungun and Central Tapanuli Districts. *IOP Conference Series: Earth and Environmental Science*, 1494(1), 012034. <https://doi.org/10.1088/1755-1315/1494/1/012034>

BRIDGING THE CAPACITY GAP: A TAPIC FRAMEWORK ANALYSIS OF CARBON PRICING INSTRUMENTS FOR MALAYSIAN PALM OIL SECTOR

HISHAM HUSSAIN^{1*}; SUFIAN JUSOH² and LAZIANA AHMAD¹

ABSTRACT

The Malaysian palm oil (MPO) industry, an important economic pillar and the nation's third-largest export contributor, generating RM84.22 billion in revenue, faces escalating global pressure from sophisticated non-trade barriers (NTBs) and scrutiny of greenhouse gas (GHG) emissions. This study evaluates the complex implications of implementing carbon pricing instruments (CPIs) through a strategic governance lens, examining their economic, environmental, and social impacts within the high-stakes environment of international trade. Utilising a qualitative approach and the Transparency, Accountability, Participation, Integrity, and Capacity (TAPIC) framework, the study investigates how CPIs can resolve existing governance deficits, such as the "Participation Paradox" and the "Continuity Crisis", while enhancing market competitiveness and policy resilience. Key findings highlight that while CPIs introduce immediate cost implications for producers, they serve as a critical defensive mechanism against international regulatory shifts, such as carbon border adjustments. The analysis emphasises the necessity of the MPO Trade Governance Framework (MPO-TGF) and an enhanced Malaysian Sustainable Palm Oil (MSPO) certification to institutionalise carbon-related technical justifications within Free Trade Agreements (FTAs). Ultimately, this study highlights the transformative potential of CPIs to position MPO as a global leader in sustainable, low-carbon production, ensuring long-term national economic resilience and global competitiveness.

Keywords: carbon pricing, Malaysian palm oil (MPO), Malaysian Sustainable Palm Oil (MSPO), TAPIC framework, trade governance.

Received: 25 February 2026; **Accepted:** 28 July 2026; **Published online:** 26 August 2026.

INTRODUCTION

The Malaysian palm oil (MPO) industry stands as a vital cornerstone of the national economy, consistently ranking as the third-largest export contributor and generating substantial revenue. In the competitive global landscape of 2026, MPO and its derivatives reach over 187 countries, maintaining a dominant market share of 25.5%

in global production and 43.3% in worldwide exports (Abdul Razak et al., 2024; Malaysian Palm Oil Board [MPOB], 2025; Mielke, 2017). This economic powerhouse generates significant benefits, contributing RM84.22 billion in export revenue as of 2025 (Malaysia External Trade Development Corporation [MATRADE], 2026). The sector's output is highly diversified, with palm oil accounting for 62% of exports, followed by oleochemicals (12%), palm kernel cake (9%), and palm kernel oil (4%).

However, this dominant economic position is increasingly challenged by the industry's environmental footprint, primarily stemming from land-use changes and production processes (Renner et al., 2008; Thangavelu & Yee, 2017; Zhao et al., 2024). To navigate these pressures, the Malaysian

¹ Malaysian Palm Oil Board,
6, Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.

² Institute of Malaysian and International Studies,
Universiti Kebangsaan Malaysia (UKM),
43600 Bangi, Selangor, Malaysia.

* Corresponding author e-mail: hishamhussain@mpob.gov.my

government has committed to ambitious climate goals under the Paris Agreement, aiming to reduce gross domestic product (GDP) carbon intensity by 45% by 2030 and achieve net-zero emissions by 2050 (Securities Commission Malaysia, 2024). Current strategies in complying with the Paris Agreement include capping total planted area at 6.5 million hectares, prohibiting new peatland plantations, and banning forest conversion (Naidu et al., 2024). Furthermore, Malaysia strives to maintain at least 50% forest cover and conserve biodiversity in alignment with the United Nation's (UN) 2030 Agenda for Sustainable Development (Malaysian Investment Development Authority [MIDA], 2024).

In this high-stakes environment, carbon pricing instruments (CPIs) have emerged as a primary mechanism to integrate environmental sustainability with economic growth. A CPI assigns a monetary value to greenhouse gas (GHG) emissions, creating financial incentives for industries to reduce their carbon output (Agnolucci et al., 2024; Pryor, 2021; Stern et al., 2022). While physical carbon itself is not typically traded in these markets, carbon credits serve as tradable certificates that businesses use to account for and balance their emissions on financial statements. Each carbon credit represents the reduction or removal of 1 t of carbon dioxide (CO₂) from the atmosphere or the prevention of 1 t of CO₂ emissions (Pryor, 2021). For Malaysia, carbon pricing is emerging as an important tool in addressing climate change, as demonstrated by Shahul Hamid et al. (2026), particularly for high-emission sectors like the oil palm sector (Tengku Hamzah et al., 2019).

The CPI can be implemented in various forms, including carbon taxes, cap-and-trade systems, and hybrid approaches, each balancing the trade-off between cost certainty and emissions reduction outcomes (Agnolucci et al., 2024; Voo & Chow, 2024). By assigning a cost to GHG emissions, CPIs offer opportunities for sustainable development in the MPO sector, supporting emission reductions, enhancing environmental accountability, and potentially generating new revenue streams through carbon markets (Judijanto, 2025; Tengku Hamzah et al., 2019).

Malaysia has committed to reducing its carbon emission intensity by 45% by 2030 compared to 2005 levels and aims to achieve carbon neutrality by 2050 (Rao et al., 2025; Suskind et al., 2020; Weber et al., 2024). The country has identified carbon capture and storage (CCS) as a key strategy to reduce emissions from its energy sector, with the potential to cut 60% of the sector's total emissions (Ministry of Natural Resources, Environment and Climate Change [NRECC], 2022; Nasir & Go, 2024). While these removals are primarily driven by forests, mangroves, and peatlands, the oil

palm sector plays a complementary role through sustainable plantation practices, reforestation of degraded land, and adoption of good agricultural practices (GAP), thereby enhancing the country's overall carbon sequestration and climate mitigation efforts.

The Malaysian Government's Readiness Support Plan (RSP), approved by the Partnership for Market Implementation in August 2022 with support from the World Bank, signals a commitment to developing CPIs and improving stakeholder understanding. However, the specific involvement of the oil palm sector and the MPOB in these initiatives remains unclear. Malaysia's approach to carbon pricing is complex, with voluntary mechanisms under Bursa Malaysia and regionally diverse carbon pricing models that differ in design and objectives (Tengku Hamzah et al., 2019). These discrepancies create uncertainty within the oil palm sector regarding applicable policies. Moreover, regulators face challenges in evaluating and standardising these varied carbon pricing models, and imposing metrics to aggregate and compare diverse CPI frameworks (Bellassen et al., 2015; Jackson et al., 2018). This review aims to explore the policy governance mechanisms surrounding CPIs in Malaysia, particularly as they apply to the oil palm sector, and to provide policy recommendations for effectively integrating CPIs into the MPO industry to promote environmental and economic benefits.

MATERIALS AND METHODS

Materials

This study adopts a robust qualitative approach to assess the multi-dimensional implications of CPIs on the MPO sector. The study synthesises primary and secondary information from a wide array of literature, official policy documents, and industry reports spanning from 2024 to 2026. Data sources include the MPOB, MATRADE, MIDA, NRECC, the World Bank, and the Securities Commission. Key policy frameworks examined include the National Sustainability Reporting Framework (NSRF), the National Energy Transition Roadmap (NETR), and the Malaysian Sustainable Palm Oil (MSPO) certification scheme, which collectively guide current sustainability and carbon management practices.

Methodology

The methodology employs a multi-staged qualitative approach that integrates a comprehensive literature synthesis, policy document analysis, and framework application.

The literature and policy review was conducted to establish a robust evidence base, synthesising peer-reviewed journals, official national policies, and industry reports from 2024 to 2026. Key governance and socio-economic themes relating to CPIs within the palm oil sector were extracted and aggregated. Building upon this foundational data, the study utilises the Transparency, Accountability, Participation, Integrity, and Capacity (TAPIC) framework (originally developed by the European Observatory on Health Systems and Policies) as a diagnostic tool to evaluate the internal executive machinery governing Malaysia's trade and carbon policy (Jarman, 2017).

This study adapts TAPIC to evaluate the structural integrity of trade and carbon policymaking through five interrelated dimensions: Transparency, which ensures that stakeholders are informed of the grounds and processes behind upcoming decisions; Accountability, which establishes formal relationships where agencies must justify their actions to a mandate-holding forum; Participation, ensuring that affected parties, such as smallholders and technical experts, acquire a meaningful stake in the work of the institution; Integrity, which provides clear, predictable roles and enforcement processes to mitigate conflicts of interest; and Capacity, which measures the institution's ability to align resources with policy goals effectively. By applying this framework, the study distinguishes whether current trade and carbon policies are shaped by secretive, ad hoc executive actions or by inclusive, institutionalised governance.

Data segments are categorised through deductive thematic coding to identify structural governance gaps, such as the "Participation Paradox" and "Continuity Crisis," which hinder the industry's strategic defence. Furthermore, the study applies the MPO Trade Governance

Framework (MPO-TGF) logic to map the implementation of carbon pricing across the three phases of the trade negotiation lifecycle: Phase 1: Pre-Negotiation (Strategic Alignment), Phase 2: Negotiation (Real-Time Coordination), and Phase 3: Implementation and Post-Negotiation (Policy Resilience). This integrated approach ensures that the findings are grounded in actual Malaysian trade diplomacy, providing insights to inform effective CPI implementation in the sector (*Figure 1*).

RESULTS AND DISCUSSION

Impact Analysis of Carbon Pricing on the MPO Industry

The implementation of CPIs in the MPO industry is anticipated to have various effects, influencing the sector's economic performance, environmental impact and social landscape. This section examines the economic, environmental, and social impacts of CPIs in the context of Malaysia's palm oil industry, as well as the role of the MSPO certification in supporting or adapting to these policies.

Economic Impact

The introduction of CPIs, such as carbon taxes and cap-and-trade systems, introduces new financial costs to emissions-intensive industries like palm oil. These operational expenses may require producers to allocate significant funds to adopt sustainable practices, invest in emissions-reducing technologies, or purchase carbon credits to offset their carbon footprint. Small-scale producers, often operating on limited budgets, may face significant hurdles in absorbing these costs (Bassi et al., 2009; Halim et al., 2019).

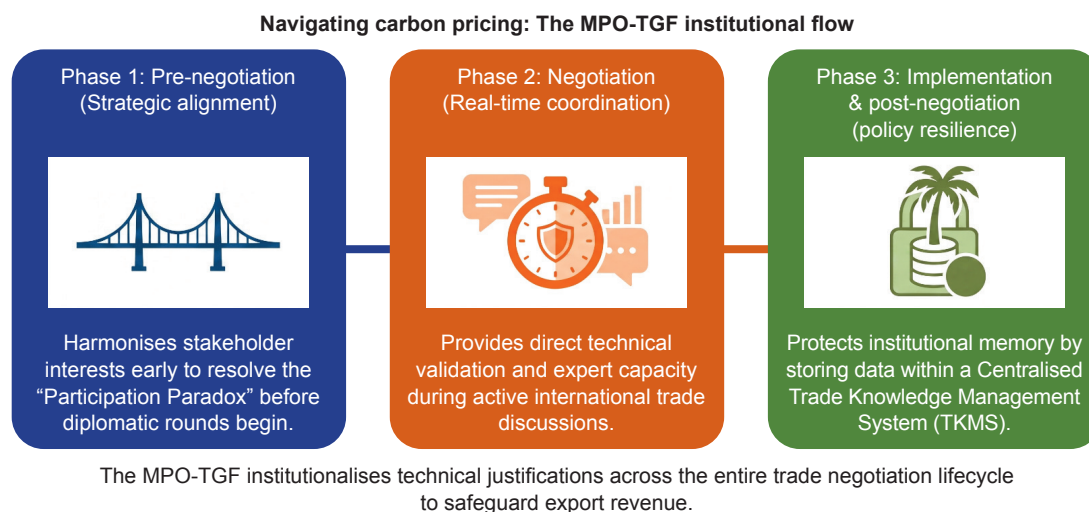


Figure 1. The customised MPO-TGF institutional flow.

Furthermore, CPIs are projected to fundamentally adjust the competitive positioning of the MPO in the global marketplace. As higher carbon pricing internalises the financial burden of emissions, production costs and unit prices of palm products are expected to rise, necessitating a shift in long-term pricing strategies (Mohamad, 2024). Although these increases may initially constrain competitiveness against producers in unregulated jurisdictions, the transition represents a strategic investment in trade resilience (Wettestad, 2009). In a 2026 trade landscape defined by carbon border adjustments, and sophisticated non-trade barriers (NTBs), proactive carbon reduction serves as a critical defensive mechanism to safeguard Malaysia's RM84.22 billion in export revenue.

By transitioning from traditional price-based competition to value-based advocacy, Malaysia can effectively mitigate the risks of international regulatory exclusion. Ultimately, this strategic posture enhances MPO's reputation in premium markets, such as the European Union (EU), attracting global buyers willing to pay a premium for certified, low-carbon commodities that meet high-integrity sustainability benchmarks (Tan et al., 2024).

Policy Governance and Strategic Trade Alignment

To effectively manage these economic shifts, MPO trade governance must evolve from a domestic environmental focus into a robust strategic trade defence mechanism. The current accountability structure in trade negotiations is predominantly executive-centric, which often bypasses the essential technical scrutiny of subject matter experts at the agency level when sustainability chapters in FTAs are drafted. The application of the TAPIC framework as a diagnostic tool reveals that the industry's vulnerability to international regulatory shifts is rooted in specific governance-based barriers rather than technical inability.

Transparency. Communication typically follows a "top-down cascade", creating information silos that prevent lead negotiators from accessing the granular technical data held by agencies like MPOB.

Accountability. The lack of a decentralised accountability structure means that technical justifications for carbon projects are often lost in translation during high-level diplomatic rounds.

Participation. A persistent "Participation Paradox" exists where technical experts are consulted only at the peripheries of negotiation rounds, distancing them from the critical decision points that define carbon border adjustments.

Integrity. The "Continuity Crisis," fuelled by frequent rotations of administrative personnel, leads to the erosion of institutional memory, making it nearly impossible to sustain the long-term strategic logic required for carbon sequestration and reforestation initiatives.

Capacity. Significant imbalances in technical-legal expertise hinder the ability of technical agencies to directly defend nuanced provisions within complex negotiation chapters, such as Trade in Goods (TIG).

Strategic alignment requires the operationalisation of the MPO-TGF to bridge these gaps. This framework serves as the institutional vehicle for the TAPIC pillars: Phase 1 (Pre-Negotiation) resolves the "Participation Paradox" by harmonising interests early; Phase 2 (Active Negotiation) ensures real-time technical validation and capacity; and Phase 3 (Implementation and Evaluation) solves the "Continuity Crisis" by institutionalising data within a centralised Trade Knowledge Management System (TKMS). This systematic integration ensures that Malaysia's carbon credentials are not just documented but are actively and consistently defended to protect the nation's RM84.22 billion in export revenue.

Environmental Impact

A key objective of carbon pricing is to reduce GHG emissions by encouraging industries to adopt cleaner and more sustainable practices. As highlighted by Radulescu et al. (2025), the establishment of a robust regulatory framework and strong commitment to carbon pricing are critical for ensuring consistent enforcement across all stakeholders, ultimately leading to significant positive environmental outcomes. In this context, environmental taxes, when combined with carbon pricing mechanisms and innovations such as green patents, can serve as powerful incentives for stakeholders to transition toward sustainable practices and low-emission technologies. For the MPO industry, this could mean transitioning to more sustainable land use practices, reducing deforestation and minimising emissions from production and processing activities (Sulong et al., 2021; Thangavelu & Yee, 2017; Yusop, 2022). CPIs, implemented through mechanisms such as carbon taxes and cap-and-trade systems, establish financial frameworks that incentivise firms to invest in decarbonisation technologies (Dill, 2024). These instruments facilitate the adoption of green innovations, most notably methane capture systems in palm oil mills and advanced agricultural techniques such as precision agriculture and enhanced soil management (Bharti et al., 2024).

Beyond direct GHG reductions, these transitions strengthen operational productivity through resource conservation, ultimately securing the long-term economic and environmental viability of the MPO industry. By integrating such advancements, the MPO industry can effectively align its production processes with national climate targets and international sustainability trends, ensuring its continued leadership in responsible agricultural production (Tan et al., 2024).

Malaysia has established climate targets as part of its strategic transition toward a low-carbon economy. Central to its Nationally Determined Contributions (NDCs) under the Paris Agreement is the commitment to reduce GDP carbon intensity by 45% by 2030 and achieve net-zero emissions by 2050. Given its substantial scale and contribution to national emissions, the MPO industry represents a critical area for mitigation efforts (Toh et al., 2025; Vaicondam et al., 2025). By adopting CPIs in high-emission sectors like palm oil, Malaysia can make significant progress toward these climate goals. The palm oil industry, given its scale and contribution to national emissions, represents a crucial area for emissions reduction efforts. By aligning the sector's practices with Malaysia's climate commitments, CPIs could help the country meet its international pledges, including those under the Paris Agreement. Furthermore, reducing emissions from palm oil production could enhance Malaysia's standing in the global climate arena, showcasing the country's commitment to sustainability and responsible agricultural practices (Goh et al., 2025; Sulin et al., 2025).

Social Impact

The palm oil industry supports millions of livelihoods in Malaysia, from plantation workers to smallholder farmers. CPIs could have varied effects on these stakeholders, depending on how the costs are distributed and the support provided for sustainable practices (Osman et al., 2019). For example, according to Solidaridad (2023), smallholders may face difficulties meeting the requirements for carbon reduction, as sustainable practices often require investment of time, new technologies, certifications or training. To ensure equitable outcomes, policy frameworks may need to incorporate subsidies, grants or technical assistance for smallholders and local communities to adapt to carbon policies (Mohamad, 2024). If well-managed, CPIs could foster community resilience by promoting environmentally sound practices, protecting biodiversity, and supporting sustainable livelihoods. On the other hand, if poorly managed, they could exacerbate inequalities by placing an unjustifiable burden on the most vulnerable stakeholders in the oil palm sector.

Carbon pricing could indirectly influence employment patterns in the oil palm sector. As companies invest in new technologies and practices to reduce emissions, demand for skilled workers in areas such as sustainable agriculture, emissions management and carbon accounting may increase (Hamid et al., 2024; Renner et al., 2008). Conversely, if certain practices or processes become economically unviable under CPIs, employment in those areas may decline, potentially leading to shifts in the workforce. Ensuring a just transition for workers may require policy support for retraining and upskilling programs, preparing the workforce for roles that align with a low-carbon economy. These measures could help mitigate adverse employment impacts and ensure that the benefits of CPIs are widely shared among workers and communities (Errendal et al., 2023).

Impact on the MSPO Certification

The MSPO certification, which sets standards for sustainable practices in palm oil production, could play an essential role in aligning the industry with carbon pricing policies. As MSPO certification already promotes environmentally responsible practices, it could serve as a foundation for the integration of carbon policies, helping producers align with CPIs' requirements more seamlessly (Sulong et al., 2021; Yusop, 2022). The MSPO framework could be adapted to include carbon management practices, thereby reducing emissions and supporting compliance with national carbon reduction goals. For instance, MSPO could establish guidelines on emissions monitoring, reporting and verification for carbon credits, assisting producers in tracking their emissions and participating in carbon markets.

Furthermore, MSPO certification could bolster the market appeal of MPO by highlighting the sector's commitment to both sustainable and low-carbon practices. This would be particularly advantageous in international markets where buyers prioritise environmentally certified products. However, incorporating carbon criteria into MSPO may also impose additional training and financial resources for smallholders and smaller producers, who may struggle to meet the enhanced standards. Addressing these challenges may require capacity-building programs, financial assistance or incentives to support widespread adoption of the enhanced MSPO certification.

With MSPO emphasising a low-carbon footprint, it could significantly enhance the consumer appeal of Malaysian palm products by adapting to growing market demands for sustainable, environmentally friendly products. Aligning MSPO standards with consumer preferences for low-carbon commodities adds a critical consumer-centric proposition to

the certification's objectives. The alignment not only reinforces the sustainability narrative of Malaysian palm-based products but also enhances its reputation and competitiveness in global markets where environmental credentials are highly recognised.

To capitalise on these opportunities, the oil palm sector should prioritise international market demands for low-carbon products by incorporating targeted strategies within the MSPO framework. This could consist of consumer awareness campaigns showcasing the low-carbon credentials of MSPO-certified palm oil. Such initiatives could leverage the industry's global reputation and strengthen its market positioning as a leader in sustainable and low-carbon palm oil production.

The potential impacts of CPIs on the MPO sector extend beyond emission reduction objectives and involve various economic, environmental, operational and social considerations. These multi-dimensional impacts synthesised from qualitative analysis of TAPIC governance dimensions, MSPO standards and Malaysian trade policy objectives are summarised in *Table 1*.

Challenges and Barriers to Implementing CPIs in MPO Industry

Despite the strategic benefits, implementing CPIs in the MPO industry faces multi-dimensional

barriers spanning political, economic, social, institutional and infrastructural dimensions. While Malaysia's carbon governance framework increasingly aligns with international standards like the International Sustainability Standards Board (ISSB), institutional predicaments, notably the absence of a unified regulatory framework and coordination gaps between lead agencies, complicate policy alignment.

As illustrated in *Figure 2*, the barriers hindering the effective implementation of CPIs in the MPO industry span five interconnected dimensions.

Political. The implementation of CPIs requires strong governmental commitment and policy consistency, which can be challenging in the face of competing priorities. Policymakers must balance environmental goals with economic growth and industry support, especially since the oil palm sector is a significant contributor to Malaysia's GDP and employment. Any policies perceived as increasing operational costs or reducing competitiveness can face resistance, not only from industry stakeholders but also from political parties concerned with economic growth. Additionally, political pressures from rural communities reliant on the palm oil industry, along with lobbying from large corporations, can further complicate efforts to enforce stringent carbon policies.

TABLE 1. MULTI-DIMENSIONAL IMPACT MATRIX OF CARBON PRICING INSTRUMENTS (CPIs) ON THE MALAYSIAN PALM OIL (MPO) SECTOR

Impact dimension	Key opportunities/strategic benefits	Primary operational and financial risk	Recommended governance and policy mitigation
Economic	Potential premium pricing in the EU and other global markets; stronger trade defence against NTBs and carbon border adjustment measures.	High initial operational and compliance costs; possible price disadvantage relative to producers in less regulated jurisdictions.	Shift from price-based competition to value-based advocacy; operationalise the MPO-TGF to support market access and trade resilience.
Environmental	Decarbonisation through methane capture, precision agriculture, and improved resource efficiency; stronger alignment with Paris Agreement targets.	Risk of greenwashing if carbon offsets are used without prioritising direct emissions reductions.	Adopt science-based targets that prioritise internal decarbonisation before using high-integrity offsets for residual emissions.
Social	Creation of new employment opportunities in sustainable agriculture, carbon accounting, emissions management, and green technologies.	Disproportionate financial burden on smallholders; potential displacement or reskilling needs among workers in traditional roles.	Provide targeted subsidies, grants, technical assistance, capacity-building, and retraining programmes to support a just transition.
MSPO certification	Enhanced international market appeal; stronger platform for carbon accounting, monitoring, reporting, and verification.	Financial and technical barriers may limit smallholder readiness and compliance with enhanced carbon-related requirements.	Integrate carbon criteria into MSPO standards while providing targeted support to strengthen smallholder participation and compliance.

Note: EU - European Union; NTBs - non-trade barriers; MPO-TGF – Malaysian Palm Oil-Trade Governance Framework; MSPO - Malaysian Sustainable Palm Oil.

Navigating the Barriers: A Diagnostic Taxonomy of Carbon Pricing in Malaysian Palm Oil



Figure 2. Diagnostic taxonomy of implementation barriers.

Economic. CPIs introduce new financial challenges for palm oil producers, particularly smallholders and small and medium-sized enterprises with limited financial flexibility. The expenses associated with acquiring carbon credits, adopting low-emission technologies or meeting stringent compliance standards could disproportionately affect these smallholders, aggravating inequalities within the sector (Radulescu et al., 2025). Larger corporations, with their greater financial capacity, are better positioned to manage these costs, potentially passing them onto consumers or leveraging economies of scale. Additionally, the introduction of carbon-related costs risks diminishing Malaysia's international competitiveness in the palm oil market. Higher production costs could make MPO less attractive compared to producers in countries without similar carbon pricing frameworks, potentially jeopardising market share and revenue streams.

Social. CPIs could reshape the dynamics of local communities and the workforce in the palm oil industry. Communities that depend heavily on the sector for employment and income may face disruptions as companies adapt their operations to meet emissions targets. Financial pressures from carbon pricing could prompt some companies to streamline operations, potentially leading to reduced employment opportunities or shifts in labour demand. This poses risks of job insecurity and income instability, particularly for vulnerable workers in the industry. Addressing these social challenges will require proactive measures, such

as workforce retraining programs, income support mechanisms, and policies to ensure a just transition that safeguards livelihoods while promoting low-carbon practices.

Institutional. Pose significant challenges to the effective implementation of CPIs in Malaysia. Effective carbon pricing requires a well-established framework for monitoring, reporting and verification of emissions, as well as regulatory oversight to ensure compliance. Currently, the absence of a unified regulatory framework for CPIs in Malaysia, along with limited experience in carbon market operations, hinders efficient policy enforcement. Additionally, there may be insufficient coordination between governmental agencies, which further complicates the alignment of CPIs with existing environmental policies.

Infrastructural. Implementing CPIs also requires significant infrastructural investments to support low-carbon technologies and sustainable practices in the palm oil sector. Many smallholders and local producers lack access to technology, training and financial resources needed to adopt emissions-reducing practices. The lack of infrastructure for carbon capture, emissions tracking and energy-efficient processing facilities creates additional obstacles, particularly for rural plantations. Without substantial support for technological upgrades and infrastructural development, these producers may struggle to meet the requirements of a carbon pricing regime.

Digital monitoring tools can enhance the MPO industry's capacity for carbon accounting and compliance with CPIs. Developing a centralised digital platform for emissions reporting can increase transparency and aid smallholders in navigating reporting requirements. Digitalisation addresses infrastructural and institutional barriers, particularly regarding monitoring, reporting and compliance. Insights on digital tools can enhance discussions about overcoming barriers to CPIs implementation.

Recommendations for Policy Enhancement

As a primary corrective measure, MPOB should spearhead the industry-wide deployment of cost-effective carbon reduction technologies, thereby scaling sustainable practices across the palm oil value chain. This intervention is crucial to facilitate more equitable participation in CPIs for both smallholders and large corporations, while simultaneously aligning the sector with shifting global sustainability mandates. Ultimately, this technological integration safeguards the environment while unlocking supplemental revenue streams through international carbon markets (Romito et al., 2024; Stern et al., 2022).

A critical component of this strategy is the adoption of the Science-Based Targets initiative (SBTi), which encourages organisations to set emission reduction goals aligned with the Paris Agreement's 1.5°C target (Romito et al., 2024). By prioritising internal decarbonisation before turning to carbon credits as a secondary measure, businesses avoid "greenwashing" concerns and demonstrate a genuine commitment to science-driven climate action. After significant direct reductions are achieved, high-integrity carbon credits can then be utilised to offset residual emissions, thereby strengthening environmental credibility within a responsible climate strategy (Bernasconi, 2021; Chu & Yuan, 2025; Maloney & Busch, 2024).

If a company were to purchase carbon credits without prioritising internal reductions, it might appear as though they are addressing the issue, but this approach does not tackle the core problem: The direct emissions generated by their activities. This can raise concerns about "greenwashing," where an organisation is perceived as offsetting emissions rather than committing to real, sustainable changes. By following the SBTi framework, businesses demonstrate that they are taking meaningful, science-driven steps toward decarbonisation. After significant reductions have been achieved, carbon credits can be used to offset any remaining emissions that are difficult to eliminate. This method not only strengthens a company's environmental credibility but also ensures that carbon credit purchases are part of a broader, more responsible climate strategy.

However, the effectiveness of CPIs in the agricultural sector remains dependent on careful

policy design to address sector-specific hurdles such as high transaction costs and leakage risks. Consequently, Malaysian policies must integrate science-based targets with targeted support mechanisms including subsidies, grants, and capacity-building programs to ensure a "Just Transition" for the workforce. While certain traditional processes may become economically unviable, these shifts simultaneously create new demand for skilled labour in specialised fields like carbon accounting and emissions management (Grosjean et al., 2018; Tvinnereim & Mehling, 2018).

Integrating the MPO-TGF logic into social policy is vital to resolving the "Participation Paradox" by ensuring smallholders and local communities have a "meaningful stake" in the decision-making process during Phase 1 (Pre-Negotiation) of CPI implementation. By fostering community resilience and protecting biodiversity through well-managed governance, Malaysia can ensure that the economic benefits of a low-carbon economy are shared rightfully across the entire palm oil supply chain.

The roadmap outlined in *Figure 3* presents a three-phased operational trajectory for transitioning the MPO industry into a resilient, low-carbon sector. Phase 1 focuses on upstream direct emissions reduction using the SBTi framework alongside circular economy practices. Phase 2 institutionalises these practices by updating MSPO standards with digital Measurement, Reporting, and Verification (MRV) mechanisms designed to protect smallholders from exclusion. Finally, Phase 3 leverages the MPO-TGF and a centralised TKMS to systematically defend Malaysia's carbon credentials in international trade negotiations and neutralise prospective carbon border taxes.

Prospects and Innovations for MPOB

MPOB has identified significant interest from various stakeholders in carbon project initiatives within the oil palm sector, aimed at offsetting emissions or trading credits in emerging markets. To capitalise on these opportunities, the board focuses its advocacy on three nature-based and innovation-driven pathways: reforestation within plantation areas, replanting of high-yielding varieties and circular economy initiatives in the downstream industry. These projects serve to enhance carbon sequestration while aligning the sector with Malaysia's GHG reduction targets and international sustainability trends.

Reforestation and Upstream Carbon Management

Reforestation within oil palm plantations represents a promising approach to maximising the industry's carbon capture capacity by rehabilitating underutilised or degraded land into

Roadmap to Resilience: Decarbonising Malaysian Palm Oil

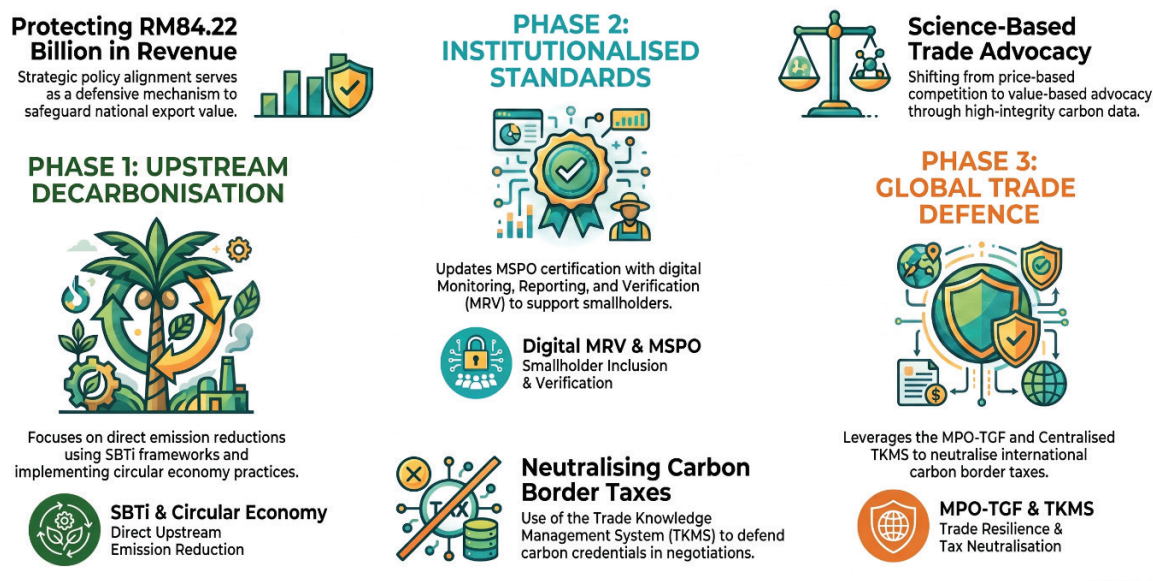


Figure 3. Strategic Decarbonisation and Policy Resilience Roadmap for the Malaysian Palm Oil (MPO) Sector.

forest ecosystems. As these forests serve as long-term carbon sinks, they store significant carbon in biomass and soil while delivering critical co-benefits such as biodiversity conservation. From an economic perspective, the carbon credits generated through these reforestation efforts can be traded in voluntary carbon markets, offering plantation operators a diversified revenue stream that reinforces the industry's reputation as a sustainable contributor to global climate goals.

Replantation Strategies and Technical Additionality

Replantation projects, particularly the replacement of ageing oil palm trees with younger, high-yielding varieties, offer a dual benefit of improving plantation productivity and enhancing ecosystem health. Efforts that incorporate diversified cropping systems, such as intercropping with other trees, further reduce the carbon footprint of oil palm cultivation. Improved land management and soil quality contribute to the "additionality" criteria required in carbon projects, making downstream products significantly more attractive to international buyers prioritising low-carbon commodities.

Circular Economy Models in the Downstream Industry

To complement upstream carbon reduction, MPOB drives circular economy projects downstream by promoting waste recycling, and byproduct utilisation. Transforming byproducts like empty fruit bunches (EFB) and palm oil mill effluent

(POME) into bio-based products or energy sources minimises waste and adds value to the supply chain. Furthermore, study into biodegradable packaging for palm oil products opens new markets and reinforces the industry's commitment to sustainable lifecycle management, providing new revenue streams while improving environmental credentials.

Strategic Integration and Policy Resilience

Within the proposed MPO-TGF, these innovations are essential components of Phase 3: Implementation and Post-Evaluation (Policy Resilience). By institutionalising the data and strategic logic of these reforestation and circular projects within a centralised TKMS, the industry can safeguard its environmental technical justifications against the risks of personnel turnover. This structural approach ensures that Malaysia's carbon sequestration potential is consistently leveraged as a competitive advantage in global trade negotiations.

CONCLUSION

This study evaluates the policy governance mechanisms surrounding CPIs in the MPO sector, identifying that the primary challenges to a sustainable transition are structural and governance-based rather than only technical. The study confirms that while the industry remains a dominant economic powerhouse, it is increasingly vulnerable to sophisticated global NTBs and carbon border adjustments due to existing governance deficits.

By applying the TAPIC framework, the analysis identifies critical gaps, specifically the “Participation Paradox” and the “Continuity Crisis”, which deter the industry’s ability to defend its technical environmental interests during high-stakes trade negotiations. To ensure policy resilience and long-term global competitiveness, this review emphasises the necessity of the MPO-TGF. This three-phased institutional approach allows for the systematic integration of technical subjects, such as reforestation, replanting, and circular economy data, within a centralised TKMS to safeguard institutional memory.

MPOB holds a fundamental role in steering the industry toward a low-carbon future by actively encouraging stakeholders to engage in nature-based solutions that align with Malaysia’s commitments under the Paris Agreement and the goal of net-zero emissions by 2050. From an economic perspective, the strategic implementation of CPIs presents transformative opportunities to unlock new revenue streams through tradable carbon credits, enhancing competitiveness in markets where low-carbon products are prioritised.

To facilitate this dynamic transition, MPOB is uniquely positioned to adopt a comprehensive and inclusive approach, implementing capacity-building programs, and establishing financial incentives to ensure equitable access for smallholders. Aligning these efforts by integrating robust carbon management practices into the MSPO 2022 certification framework is critical for reinforcing Malaysia’s commitment to environmental stewardship and future-proofing the sector against evolving regulatory requirements. Ultimately, by addressing compliance barriers and leveraging innovations, the MPO industry can solidify its position as a global leader in sustainable agriculture, securing its long-term viability and contributing significantly to national climate ambitions.

ACKNOWLEDGEMENT

The authors would like to thank the Director-General of MPOB for the permission to publish this review. The figures were generated with the assistance of NotebookLM based on the authors’ concepts and ideas. The authors take full responsibility for the final content and accuracy of the figures.

REFERENCES

Abdul Razak, S. E., Mustapha, M., Mohammed Shah, S., & Abu Kasim, N. A. (2024). Sustainability risk management: Are Malaysian companies ready? *Heliyon*, 10(3), e24681. <https://doi.org/10.1016/j.heliyon.2024.e24681>

- Agnolucci, P., Fischer, C., Heine, D., Leon, M. M. D. O., Pryor, J., Patroni, K., & Hallegatte, S. (2024). Measuring total carbon pricing. *The World Bank Research Observer*, 39(2), 227–258. <https://doi.org/10.1093/wbro/lkad009>
- Bassi, A. M., Yudken, J. S., & Ruth, M. (2009). Climate policy impacts on the competitiveness of energy-intensive manufacturing sectors. *Energy Policy*, 37(8), 3052–3060. <https://doi.org/10.1016/j.enpol.2009.03.055>
- Bellassen, V., Stephan, N., Afriat, M., Alberola, E., Barker, A., Chang, J.-P., Chiquet, C., Cochran, I., Deheza, M., Dimopoulos, C., Foucherot, C., Jacquier, G., Morel, R., Robinson, R., & Shishlov, I. (2015). Monitoring, reporting and verifying emissions in the climate economy. *Nature Climate Change*, 5(4), 319–328. <https://doi.org/10.1038/nclimate2544>
- Bernasconi, L. (2021). A natural approach to net zero. In T. Heller, & A. Seiger (Eds.) *Settling climate accounts: Navigating the road to net zero* (pp. 121–144). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-83650-4_7
- Bharti, M., Baswaraju, S., Nijhawan, G., Sharma, N., Kumar, A., Mashkour, M. S., & Nalli, N. (2024). Reduction of green house gases emission: Towards a sustainable future. *E3S Web of Conferences*, 552, 01116. <https://doi.org/10.1051/e3sconf/202455201116>
- Chu, H., & Yuan, S. (2025). Carbon credit does not buy moral credit: Moral licensing and perceived hypocrisy of carbon emission offsetting and reduction. *Climatic Change*, 178(3), 48. <https://doi.org/10.1007/S10584-025-03897-5>
- Dill, H. (2024). Carbon pricing initiatives and green bonds: Are they contributing to the transition to a low-carbon economy? *Climate Policy*, 24(4), 529–544. <https://doi.org/10.1080/14693062.2023.2210107>
- Errendal, S., Ellis, J., & Jeudy-Hugo, S. (2023). *The role of carbon pricing in transforming pathways to reach net zero emissions: Insights from current experiences and potential application to food systems* (OECD Environment Working Papers, No. 220). OECD Publishing. <https://doi.org/10.1787/5cefd8c-en>
- Goh, K. C., Kurniawan, T. A., AlSultan, G. A., Othman, M. H. D., Anouzla, A., Aziz, F., Ali, I., Casila, J. C. C., Khan, M. I., Zhang, D., Onn, C. W., Seow, T. W., & Shafii, H.

- (2025). Innovative circular bioeconomy and decarbonization approaches in palm oil waste management: A review. *Process Safety and Environmental Protection*, 195, 106746. <https://doi.org/10.1016/J.PSEP.2024.12.127>
- Grosjean, G., Fuss, S., Koch, N., Bodirsky, B. L., De Cara, S., & Acworth, W. (2018). Options to overcome the barriers to pricing European agricultural emissions. *Climate Policy*, 18(2), 151–169. <https://doi.org/10.1080/14693062.2016.1258630>
- Halim, I., Miah, J. H., Khoo, H. H., & Koh, L. (2019). Evaluating the potential impacts of carbon tax cost passing strategy on petrochemical selling prices. *SN Applied Sciences*, 1, 1490. <https://doi.org/10.1007/s42452-019-1553-6>
- Hamid, S. R., Arzaman, A. F. M., Razali, M. A., Yasin, N. I., Masrom, N. R., Sabri, N. A. A., & Margono, M. (2024). The deployment of the Malaysian sustainable palm oil standard in the agriculture sector. *Multidisciplinary Science Journal*, 6(7), e2024115. <https://doi.org/10.31893/multiscience.2024115>
- Jackson, A., Lloyd, A., Macinante, J., & Hüwener, M. (2018). Networked carbon markets. In A. Marke (Ed.), *Transforming climate finance and green investment with blockchains* (pp. 255–268). Elsevier. <https://doi.org/10.1016/B978-0-12-814447-3.00019-7>
- Jarman, H. (2017). Trade policy governance: What health policymakers and advocates need to know. *Health Policy*, 121(11), 1105–1112. <https://doi.org/10.1016/j.healthpol.2017.09.002>
- Judijanto, L. (2025). Emerging carbon capture technologies in the palm oil industry: A review of bioenergy and carbon capture storage approaches. *International Journal of Engineering, Science and Information Technology*, 5(3), 500–509. <https://doi.org/10.52088/ijesty.v5i3.1170>
- Malaysia External Trade Development Corporation. (2026). *Top 10 major export products, 2025*. <https://www.matrade.gov.my/en/about-matrade/media-release/media-release-2025/trade-performance-december-2025-and-january-december-2025>
- Malaysian Investment Development Authority. (2024, November 18). *Carbon pricing: Path towards carbon neutral growth in Malaysia*. <https://www.mida.gov.my/carbon-pricing-path-towards-carbon-neutral-growth-in-malaysia/>
- Malaysian Palm Oil Board. (2025). *Economics and Industry Development Division - Statistics*. <https://bepi.mpob.gov.my/>
- Maloney, R., & Busch, C. (2024). Framework proposal for science-aligned corporate climate action. In *2024 Electronics Goes Green 2024+ (EGG)* (pp. 1–6). IEEE. <https://doi.org/10.23919/EGG62010.2024.10631268>
- Mielke, T. (2017). World markets for vegetable oils: Status and prospects. In R. A. Meyers (Ed), *Encyclopedia of sustainability science and technology* (pp. 1–38). Springer. https://doi.org/10.1007/978-1-4939-2493-6_989-1
- Ministry of Natural Resources, Environment and Climate Change. (2022). *Malaysia fourth biennial update report under the United Nations Framework Convention on Climate Change*. https://unfccc.int/sites/default/files/resource/MY%20BUR4_2022.pdf
- Mohamad, J. (2024, October 3). *Challenges and viability of carbon pricing in Malaysia*. Stratsea. <https://stratsea.com/challenges-and-viability-of-carbon-pricing-in-malaysia/>
- Naidu, L., Mohd Huda, M. I., & Moorthy, R. (2024). Trade competitiveness and sustainability policies of Malaysian palm oil in the European Union: Strategic responses by stakeholders agencies. *Malaysian Journal of History, Politics & Strategic Studies*, 51(1), 21–36. <https://doi.org/10.17576/jebat.2024.5101.02>
- Nasir, E., & Go, Y. I. (2024). Carbon capture and storage at Malaysia power plants: Evaluation of its feasibility and requisite enablers. *Journal of Cleaner Production*, 469, 143173. <https://doi.org/10.1016/j.jclepro.2024.143173>
- Osman, S., Saini, K. M., Adura, A., Hamzah, T., Yusuf, M., Zainuddin, Z., & Sisun, A. (2019). The impacts of carbon trading in general equilibrium (GE) model: Malaysian palm oil perspective. *Pertanika Journal of Social Sciences & Humanities*, 27(4), 2843–2863.
- Pryor, J. (2021). *Introduction to carbon pricing instruments*. The World Bank Group.
- Radulescu, M., Hossain, M. R., Alofaysan, H., & Si Mohammed, K. (2025). Do emission trading systems, green technology, and environmental governance matter for environmental quality? Evidence from the European Union. *International Journal of Environmental Research*, 19(1), 6. <https://doi.org/10.1007/s41742-024-00667-6>

- Rao, T., Mustapa, S. I., Al-Amin, A. Q., & Ahmed, A. (2025). Modelling the social cost of carbon for Malaysia. *Carbon Research*, 4(1), 18. <https://doi.org/10.1007/s44246-024-00182-5>
- Renner, M., Sweeney, S., & Kubit, J. (2008). *Green jobs: Towards decent work in a sustainable, low-carbon world*. United Nations Environment Programme. <https://www.unep.org/resources/report/green-jobs-towards-decent-work-sustainable-low-carbon-world>
- Romito, S., Vurro, C., & Pogutz, S. (2024). Joining multi-stakeholder initiatives to fight climate change: The environmental impact of corporate participation in the Science Based Targets initiative. *Business Strategy and the Environment*, 33(4), 2817–2831. <https://doi.org/10.1002/bse.3639>
- Securities Commission Malaysia. (2024). *National Sustainability Reporting Framework*. <https://www.sc.com.my/api/documentms/download.ashx?id=e98c3900-7b35-4cf5-a07d-fd17acf8734e>
- Shahul Hamid, S. K., Hasanuzzaman, M., & Al Tanjil, H. (2026). Economic and environmental impact assessment of carbon storage in Malaysia. *Petroleum Research*. <https://doi.org/10.1016/j.ptlrs.2025.12.004>
- Solidaridad. (2023, September 15). *Carbon credits and carbon markets: Unlocking benefits for smallholder farmers*. <https://www.solidaridadnetwork.org/news/carbon-credits-and-carbon-markets-unlocking-benefits-for-smallholder-farmers/>
- Stern, N., Stiglitz, J., & Taylor, C. (2022). The economics of immense risk, urgent action and radical change: Towards new approaches to the economics of climate change. *Journal of Economic Methodology*, 29(3), 181–216. <https://doi.org/10.1080/1350178X.2022.2040740>
- Sulin, S. N., Mokhtar, M. N., Baharuddin, A. S., & Mohammed, M. A. P. (2025). Simulation and techno-economic evaluation of integrated palm oil mill processes for advancing a circular economy. *Cleaner Environmental Systems*, 19, 100323. <https://doi.org/10.1016/j.cesys.2025.100323>
- Sulong, R., Labansing, S. A., Sulong, R. S., & Idris, S. (2021). Sustainable certification in the Malaysian palm oil industry. *Asian Journal of Research in Business and Management*, 3(2), 119–131.
- Susskind, L., Chun, J., Goldberg, S., Gordon, J. A., Smith, G., & Zaerpoor, Y. (2020). Breaking out of carbon lock-in: Malaysia's path to decarbonization. *Frontiers in Built Environment*, 6, 21. <https://doi.org/10.3389/fbuil.2020.00021>
- Tan, Q. T., Rajakal, J. P., Lim, C. H., Hassim, M. H., & Ng, D. K. S. (2024). Toward carbon neutrality: Systematic approach to decarbonize palm oil value chain. *Industrial & Engineering Chemistry Research*, 63(4), 1903–1925. <https://doi.org/10.1021/acs.iecr.3c02405>
- Tengku Hamzah, T. A. A., Zainuddin, Z., Mohd Yusoff, M., Osman, S., Abdullah, A., Md Saini, K., & Sisun, A. (2019). The conundrum of carbon trading projects towards sustainable development: A review from the palm oil industry in Malaysia. *Energies*, 12(18), 3530. <https://doi.org/10.3390/en12183530>
- Thangavelu, I., & Yee, C. L. (2017). Creating sustainable supply chain for palm oil. *International Journal of Sustainable Agricultural Management and Informatics*, 3(2), 103–124. <https://doi.org/10.1504/IJSAMI.2017.085653>
- Toh, S. Y., Ling, G. H. T., Chau, L. W., Abdullah, R., Ho, C. S., Misnan, S. H., Matusin, A. M. R. A., & Jamirsah, N. (2025). Can Kuala Lumpur achieve carbon neutrality by 2050? *International Energy Journal*, 25(2), 327–332. <https://doi.org/10.64289/iej.25.0206.7798113>
- Tvinnereim, E., & Mehling, M. (2018). Carbon pricing and deep decarbonisation. *Energy Policy*, 121, 185–189. <https://doi.org/10.1016/j.enpol.2018.06.020>
- Vaicondam, Y., Mustafa, A. M. A. A., Roslan, S. N. M., Ming, K. L. Y., & Ramayah, M. (2025). GHG and carbon emission intensity: Examining their impact on financial performance. *International Journal of Energy Economics and Policy*, 15(1), 190–196. <https://doi.org/10.32479/ijeeep.17474>
- Voo, J., & Chow, D. S. (2024, October 17). *Carbon pricing and its role in decarbonising Malaysian*. PwC Malaysia. <https://www.pwc.com/my/en/perspective/esg/241017-carbon-pricing-in-malaysia.html>
- Weber, M., Pressburger, L., Chau, L. W., Khan, Z., Waite, T., Westphal, M. I., Ling, G. H. T., Ho, C. S., & Evans, M. (2024). Carbon neutrality in Malaysia and Kuala Lumpur: Insights from stakeholder-driven integrated assessment modeling. *Frontiers in Energy Research*, 12, 1336045. <https://doi.org/10.3389/fenrg.2024.1336045>
- Wettstad, J. (2009). EU energy-intensive industries and emission trading: Losers becoming winners?

Environmental Policy and Governance, 19(5), 309–320. <https://doi.org/10.1002/eet.516>

Yusop, I. (2022). *Principle 2 of the revised MSPO standards MS2530:2022 - Transparency*. MPOCC. <https://mspo.org.my/mspo-blogs/principle-2-of-mspo-25302022-transparency>

Zhao, Q., Yu, L., Li, X., Xu, Y., Du, Z., Kanniah, K., Li, C., Cai, W., Lin, H., Peng, D., Zhang, Y., & Gong, P. (2024). The expansion and remaining suitable areas of global oil palm plantations. *Global Sustainability*, 7, e9. <https://doi.org/10.1017/sus.2024.8>

FACTORS SHAPING JOB SATISFACTION AMONG LOCAL MACHINE OPERATORS IN MALAYSIA'S MECHANISED OIL PALM ESTATES

SITI ZUWAIRIAH ABDULLAH¹ and SELVAKKUMAR K N VAIAPPURI^{1*}

ABSTRACT

Previous studies on mechanised oil palm plantations have primarily focused on labour productivity, technology adoption and operational performance, with limited attention given to understanding the factors shaping job satisfaction among local machine operators who are central to mechanised field operations. Addressing this gap, this study examined the influence of plantation mechanisation, intrinsic factors, and extrinsic factors on job satisfaction among local machine operators in Malaysia's mechanised oil palm estates. Data were collected from 418 local machine operators and analysed using partial least squares structural equation modelling (PLS-SEM). The results indicate that plantation mechanisation and extrinsic factors exert significant positive effects on job satisfaction, whereas intrinsic factors do not demonstrate a significant influence. Extrinsic factors emerged as the strongest predictor of job satisfaction, followed by plantation mechanisation. The structural model explained 37.2% of the variance in job satisfaction. The findings support the relevance of the Technology Acceptance Model (TAM) and Herzberg's Two-Factor Theory in explaining job satisfaction within mechanised plantation environments. The study highlights the importance of favourable employment conditions and positive technological experiences in shaping workforce evaluations and provides practical insights to strengthen workforce satisfaction in mechanised plantation operations. The findings further suggest that technological experiences constitute an important dimension of employees' overall work evaluations within machine-dependent plantation environments.

Keywords: job satisfaction, local machine operators, mechanisation, oil palm estates, working conditions.

Received: 30 December 2025; **Accepted:** 31 July 2026; **Published online:** 15 September 2026.

INTRODUCTION

Mechanisation has become a defining feature of oil palm field operations in Malaysia as plantation organisations respond to persistent labour shortages, declining interest among younger workers, and an ageing workforce (Crowley, 2020; Ismail et al., 2024; Shahiri & Du, 2025; Thaddeus et al., 2023). National initiatives under the Twelfth Malaysia Plan have further encouraged the adoption of machinery for activities such

as spraying, manuring, harvesting support and fresh fruit bunch (FFB) transportation, positioning mechanisation as a practical strategy for addressing labour constraints while improving operational efficiency (Economic Planning Unit, 2021). Similar developments are evident globally, where agricultural mechanisation is increasingly recognised as an important approach for sustaining productivity under constrained workforce conditions (Daum, 2023; Zapata-Hernández et al., 2024).

Beyond improving operational efficiency, mechanisation fundamentally reshapes the nature of plantation work. Mechanised field operations require operators to perform specialised tasks, comply with structured operating procedures and coordinate closely with field teams, representing

¹ Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, Melaka Branch, Jasin Campus, 77300 Merlimau, Melaka, Malaysia.

* Corresponding author e-mail: selvakkumar@uitm.edu.my

a substantial departure from conventional manual plantation practices (Baur & Iles, 2023). Consequently, the effectiveness of mechanisation depends not only on machine capability but also on operators' acceptance of technology, their adaptation to machine-assisted work and the organisational conditions that support its effective implementation. Previous studies have shown that equipment unreliability, delayed maintenance and inadequate operational coordination can disrupt work routines, reduce operational efficiency and negatively influence employees' work experiences, thereby limiting the intended benefits of mechanisation (Hobbs et al., 2020; Nafea et al., 2025; Thaddeus et al., 2023).

As mechanisation becomes increasingly embedded within plantation operations, understanding employees' work experiences has become equally important. Job satisfaction is widely recognised as an important indicator of workforce stability because it reflects employees' overall evaluation of their work environment and influences their willingness to remain in their organisations (Davidescu et al., 2020; Fletcher et al., 2018). Nevertheless, previous studies on mechanised oil palm plantations have predominantly focused on labour productivity, technology adoption and operational performance, with comparatively limited attention given to understanding the factors shaping job satisfaction among local machine operators. Moreover, although studies on job satisfaction acknowledge the importance of employment conditions, studies conducted within mechanised plantation settings have generally examined technological and organisational dimensions separately. Consequently, limited evidence is available on how technological perceptions and employment conditions jointly shape job satisfaction among local machine operators in mechanised plantation environments (Ismail et al., 2024; Mohiddin et al., 2021; Ramli et al., 2023; Thaddeus et al., 2023; Zulkefli et al., 2020).

To address this gap, the present study examines the factors shaping job satisfaction among local machine operators in Malaysia's mechanised oil palm estates using an integrated analytical framework that combines the Technology Acceptance Model (TAM) and Herzberg's Two-Factor Theory. TAM explains technology-related evaluations through perceived usefulness and perceived ease of use (Davis, 1989; Davis et al., 1989), whereas Herzberg's Two-Factor Theory distinguishes intrinsic factors, including achievement, growth, and recognition, from extrinsic factors such as working conditions, job security, and salary (Herzberg et al., 1959). Although both theories have been widely applied in their respective domains, they explain different aspects of employees' work experiences. TAM

focuses on employees' evaluations of technology, whereas Herzberg's framework explains how employment conditions influence job satisfaction. Neither theory independently captures the combined influence of technological perceptions and employment conditions that characterise machine-dependent plantation work.

By integrating these complementary theoretical perspectives, this study provides a more comprehensive explanation of job satisfaction within mechanised plantation environments. Unlike previous studies, which have largely examined technological and organisational dimensions independently, the present study explains how technological perceptions and employment conditions jointly shape job satisfaction within a single analytical framework. In doing so, the study extends existing plantation research beyond labour productivity, technology adoption, and operational performance by demonstrating that operators' evaluations of technology constitute an important component of overall work evaluation alongside employment conditions. The study also contributes empirical evidence from Malaysia's mechanised oil palm estates, a context that remains underrepresented in the literature despite the industry's increasing reliance on mechanised field operations.

Within mechanised plantation operations, reliable machinery and positive technological experiences are expected to contribute to more favourable evaluations of work. Accordingly, plantation mechanisation is hypothesised to have a significant positive effect on job satisfaction (H1). Similarly, opportunities for achievement, growth, and recognition are expected to enhance operators' perceptions of their work, leading to the hypothesis that intrinsic factors positively influence job satisfaction (H2). Finally, favourable employment conditions, including supportive working environments, job security, and adequate remuneration, are expected to strengthen perceptions of organisational support and improve employees' overall work evaluations. Accordingly, extrinsic factors are hypothesised to have a significant positive effect on job satisfaction (H3).

Figure 1 presents the conceptual framework guiding the study and illustrates the proposed relationships among plantation mechanisation, intrinsic factors, extrinsic factors and job satisfaction.

MATERIALS AND METHODS

This study adopted a quantitative cross-sectional survey design to examine factors associated with job satisfaction among local machine operators in mechanised oil palm estates in Malaysia. The survey approach captured operators' perceptions of

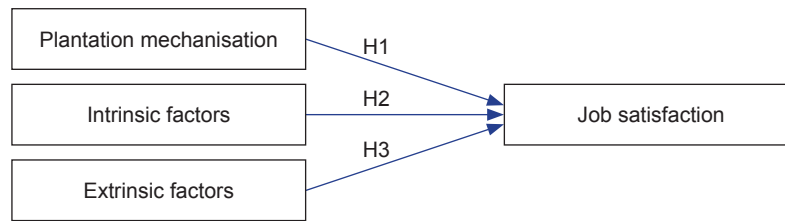


Figure 1. Conceptual framework of the study.

mechanisation, intrinsic work factors and extrinsic work conditions at a single point in time, enabling systematic assessment of relationships between the study variables within the operational context of mechanised plantation work.

Study Population and Location

The study population comprised local machine operators engaged in core mechanised field tasks, including spraying, manuring, harvesting support and FFB transportation. Estates representing a range of operational sizes and terrain characteristics were included to capture variation in mechanised deployment and field operating conditions across Malaysia.

Sampling Strategy

Sampling followed the estate-class categories established by the Malaysian Palm Oil Association (MPOA), whereby estates are classified according to operational size. A proportionate stratified sampling approach was employed to ensure proportional representation of estates across the different MPOA classifications. Eligible respondents comprised local machine operators directly involved in mechanised field operations who satisfied the predefined inclusion criteria. Through coordination with estate management, all eligible operators within each participating estate were invited to complete the survey.

This sampling strategy was designed to obtain broad coverage of local machine operators across estates with different operational sizes and mechanisation characteristics while maintaining proportional representation across the predefined estate strata. Such an approach is appropriate for heterogeneous populations because it improves the distribution of respondents across relevant subgroups and reduces the potential for disproportionate representation of any single estate category (Sekaran & Bougie, 2016). By including respondents from estates representing different MPOA classifications and diverse operational contexts, the study captured variation in mechanised plantation settings relevant to the research objectives. Although the absence of a

comprehensive national sampling frame precluded statistical generalisation to all local machine operators in Malaysia, the sampling strategy was appropriate for examining the hypothesised relationships among the study constructs within the participating mechanised oil palm estates. Survey links were distributed during morning briefings and through internal communication channels.

Instrumentation

The questionnaire measured four constructs using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Likert-type scales are well suited to capturing attitudinal and perceptual responses and are widely applied in field-based and organisational studies (Likert, 1932). The five-point scale aligns with methodological guidance for structural equation modelling using partial least squares structural equation modelling (PLS-SEM), balancing response variability with respondent ease in field survey settings (Hair et al., 2019). Measurement items were adapted from multiple previously validated instruments to ensure alignment with the study constructs and theoretical foundations. Relevant items were selected and contextually refined to reflect the operational characteristics of mechanised oil palm plantation work in Malaysia while preserving the original theoretical meaning of the measures. The adapted questionnaire subsequently underwent content validation by four subject-matter specialists, comprising two academics with expertise in research methodology and organisational behaviour and two senior plantation practitioners with experience in mechanisation and plantation operations. Feedback from the expert review was incorporated to improve item clarity, relevance and contextual appropriateness prior to pilot testing. *Table 1* summarises the constructs, dimensions and measurement sources.

A pilot test involving 38 local machine operators confirmed item clarity and demonstrated acceptable internal consistency, with Cronbach's alpha values ranging from 0.78 to 0.90, exceeding commonly accepted reliability thresholds (Nunnally & Bernstein, 1994). Feedback obtained during the pilot study, together with the preliminary reliability

TABLE 1. SUMMARY OF CONSTRUCTS AND MEASUREMENT SOURCES

Construct	Dimensions	Items	Key sources
Plantation mechanisation	Usefulness, ease of use	10	Davis (1989)
Intrinsic factors	Achievement, growth, recognition	6	Herzberg et al. (1959)
Extrinsic factors	Working conditions, job security, salary	13	Herzberg et al. (1959)
Job satisfaction	Job fulfilment, attitudinal inclination to stay, affective attachment to work	8	Weiss et al. (1967); Kamaruddin et al. (2018)

assessment, was used to refine the questionnaire prior to the main survey. Minor revisions were made to improve item wording, questionnaire presentation and administration procedures without altering the conceptual meaning or measurement intent of the original measurement items.

Data Collection

Data were collected between August and October 2025 using an online Google Form distributed through estate management communication channels. Estate management facilitated the dissemination of the survey link to eligible local machine operators via internal communication platforms, including WhatsApp and Telegram, to maximise coverage across estates and estate categories. As no comprehensive sampling frame of local machine operators was available and the survey link was disseminated through estate-level coordination rather than to a predefined list of identifiable individuals, a conventional response rate could not be calculated. A total of 423 completed questionnaires were received, of which 418 were retained for analysis following data screening.

Participation was voluntary. Before accessing the questionnaire, respondents were provided with a participant information statement outlining the study objectives, the voluntary nature of participation, the confidentiality of their responses, and their right to withdraw at any time without penalty. Electronic informed consent was obtained before respondents proceeded with the survey, and responses were completed outside active field working hours to minimise disruption to operational activities.

To minimise the potential for common method bias, several procedural controls were implemented during questionnaire design and data collection. Participation was voluntary and respondent anonymity and confidentiality were assured to reduce potential evaluation apprehension. Participants were informed that there were no right or wrong answers and were encouraged to provide honest responses. In addition, the questionnaire employed measurement items

adapted from previously validated instruments and was administered using standardised procedures across all participating estates to ensure consistency throughout the data collection process.

Although the online survey enabled data collection across geographically dispersed estates, the possibility of self-selection bias cannot be entirely excluded because participation depended on respondents' willingness to complete the questionnaire. Nevertheless, measures were implemented to minimise duplicate submissions and maintain the integrity of the dataset throughout the data collection process. Ethical approval was obtained from the Universiti Teknologi MARA Research Ethics Committee (REC/07/2025 (PG/MR/397), 22 July 2025) and all data handling procedures complied with the Malaysian Personal Data Protection Act 2010.

Data Analysis

Data screening was conducted using the Statistical Package for the Social Sciences (SPSS) and Jamovi, while PLS-SEM analyses were performed using SmartPLS 4. PLS-SEM was selected because the primary objective of this study was to examine the predictive relationships among multiple latent constructs within an integrated analytical framework rather than to evaluate overall model fit. The approach is appropriate for analysing complex structural models comprising multiple interrelated constructs and has been widely recommended for prediction-oriented research in the behavioural and social sciences (Hair et al., 2019).

Additional data screening procedures included the assessment of data normality, potential common method bias and detection of outliers. Normality was examined through skewness and kurtosis values. Potential common method bias was assessed using Harman's single-factor test based on an unrotated principal component analysis (Podsakoff et al., 2003). The first factor accounted for 38.636% of the total variance, which is below the commonly accepted threshold of 50.000%, indicating that common method bias was unlikely to pose a serious concern in this study. Outliers were identified using a two-

stage screening procedure based on standardised latent construct scores generated in SmartPLS. Cases with standardised z -scores exceeding ± 3.29 were flagged as potential outliers following the guideline of Tabachnick and Fidell (2019). Potential outliers were subsequently reviewed and cases exhibiting consistently extreme response patterns were removed. Latent construct scores were then recalculated, and a second-stage assessment confirmed that no additional cases exceeded the adopted threshold. A total of five observations were removed through this iterative procedure, resulting in a final dataset of 418 valid responses. The results indicated no severe deviations from normality and the screened dataset was subsequently analysed using PLS-SEM. Composite job satisfaction scores were classified into five ordinal levels (Very Low to Very High) using the proportional-interval method for descriptive interpretation (Boone & Boone, 2012; Joshi et al., 2015).

PLS-SEM analysis was conducted following a two-stage approach. In the first stage, the measurement model was evaluated by examining indicator reliability, internal consistency reliability, convergent validity and discriminant validity. Indicator reliability was assessed using outer loadings, while internal consistency was evaluated through Cronbach's alpha and composite reliability (CR). Convergent validity was examined using average variance extracted (AVE) and discriminant validity was assessed using the Heterotrait-Monotrait ratio (HTMT) and the Fornell-Larcker criterion. Variance inflation factors were also examined to assess potential multicollinearity.

In the second stage, the structural model was evaluated to examine the hypothesised relationships among the constructs. Structural relationships were estimated through bootstrapping with 10,000 subsamples, with t -values and p -values used to determine the significance of path coefficients. Model explanatory power was assessed using R^2 values, and effect sizes (f^2) were examined to determine the relative contribution of each predictor. This procedure enabled a systematic assessment of both the measurement quality and the structural relationships within the model. The final structural assessment was conducted using the revised measurement model specification.

RESULTS AND DISCUSSION

Respondent Profile

A total of 418 local machine operators participated in the study. The respondent profile indicates that the workforce was predominantly young, male and permanently employed. More than three-quarters of the respondents were

aged between 20 and 35 years, while male operators accounted for 95.7% of the sample. Malays represented the largest ethnic group, followed by Indigenous respondents from Sabah and Sarawak.

The respondents generally possessed practical and technical educational backgrounds, with vocational or technical qualifications representing the largest educational category. Most respondents reported monthly earnings between RM2,001 and RM2,500 and had between one and five years of work experience. Permanent employees accounted for the majority of the sample, reflecting the operational dependence of mechanised plantation activities on a stable workforce.

Fertiliser application and spraying machinery operators constituted the largest occupational groups, indicating that mechanisation is most extensively deployed within these field operations. Training exposure was generally concentrated at the basic and intermediate levels, suggesting that most operators possessed at least foundational competency in mechanised field tasks. Collectively, these characteristics indicate that the sample comprised local machine operators with diverse demographic, employment and operational backgrounds across different estate categories. These characteristics provide contextual insight into the respondents included in the study. *Table 2* summarises the demographic characteristics of the respondents.

Descriptive Statistics for Study Constructs

Descriptive statistics for all study constructs are presented in *Table 3*. Plantation mechanisation recorded generally favourable evaluations, particularly for perceived usefulness and ease of use, indicating positive perceptions of machine-assisted work. Intrinsic factors also demonstrated relatively high mean scores, reflecting favourable perceptions of achievement, growth and recognition among machine operators.

In contrast, greater variability was observed for extrinsic factors and job satisfaction. Lower scores associated with equipment reliability, salary fairness and emotional attachment suggest that perceptions of operational support and employment conditions were less consistently positive across respondents. These findings indicate that while operators generally recognised the functional benefits of mechanisation, evaluations of work conditions and overall job satisfaction remained more varied.

The descriptive results provide an initial indication that positive perceptions of mechanisation do not necessarily correspond to uniformly high levels of job satisfaction. These patterns provide an important basis for interpreting the subsequent structural model results.

TABLE 2. DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Code	Variable/Categories	Frequency (n)	Percentage (%)
G1	Age group (years)		
	20–25	112	26.79
	26–30	129	30.86
	31–35	87	20.81
	36–40	47	11.24
	41–45	29	6.94
	46–50	7	1.67
	51–55	5	1.20
	56–60	2	0.48
G2	Gender		
	Male	400	95.69
	Female	18	4.31
G3	Ethnicity		
	Malay	320	76.56
	Indian	13	3.11
	Chinese	12	2.87
	Sabah indigenous	30	7.18
	Sarawak indigenous	24	5.74
	Others	19	4.54
G4	Highest education level		
	Lower secondary	8	1.91
	SPM/O-Level	112	26.80
	Vocational/Technical	195	46.65
	STPM/Matriculation	12	2.87
	Diploma/Advanced Diploma	77	18.42
	Bachelor's Degree	14	3.35
G5	Monthly income (RM)		
	1,501–2,000	75	17.94
	2,001–2,500	230	54.98
	2,501–3,000	73	17.46
	3,001–3,500	24	5.74
	3,501–4,000	11	2.63
	4,001–4,500	3	0.72
	4,501 and above	2	0.48
G6	Work experience (years)		
	1–5	363	86.84
	6–10	33	7.89
	11–15	12	2.87
	16 and above	10	2.39
G7	Current role		
	Fertiliser machinery operator	181	43.30
	Spraying machinery operator	153	36.60
	Other field roles	64	15.31
	Technical/supervisory	20	4.78
G8	Employment type		
	Permanent	395	94.50
	Contract	23	5.50
G9	Training level		
	No formal training	5	1.20
	Basic	116	27.75
	Intermediate	153	36.60
	Advanced	108	25.84
	Expert	36	8.61

TABLE 3. DESCRIPTIVE STATISTICS FOR STUDY CONSTRUCTS

Construct	Mean range	SD range	Key interpretation
Plantation mechanisation	2.80–4.07	0.74–1.21	High usefulness; reliability concerns remain
Intrinsic factors	3.83–4.37	0.69–0.85	Favourable perceptions of achievement, growth and recognition
Extrinsic factors	2.89–4.09	0.79–1.54	Mixed perceptions of work conditions and rewards
Job satisfaction	2.61–4.05	0.71–1.46	Moderate fulfilment; weaker emotional attachment

Job Satisfaction Levels

Job satisfaction scores were grouped into five proportional-interval categories to illustrate their distribution across respondents (*Table 4*). The largest proportion of respondents was concentrated within the low (40.4%) and moderate (20.3%) satisfaction categories, while fewer respondents reported high (17.7%) or very high (14.4%) levels of job satisfaction. Only 7.2% of respondents were classified within the very low category.

Overall, the results indicate that most local machine operators reported low to moderate levels of job satisfaction despite the increasing use of mechanisation. This pattern suggests that technological improvements alone may be insufficient to generate high levels of job satisfaction and supports previous findings that favourable organisational conditions remain important in shaping positive work evaluations (Spector, 1997).

Measurement Model Assessment

The reflective measurement model was evaluated at the second-order level to represent the hierarchical structure of plantation mechanisation, intrinsic factors, extrinsic factors and job satisfaction. Convergent validity and discriminant validity were examined to establish measurement adequacy prior to structural model evaluation. Following model re-specification undertaken to address the reviewer's discriminant validity concerns, the measurement model was re-estimated and reassessed to confirm the reliability and validity of the retained construct measures.

Convergent Validity

Convergent validity was assessed using outer loadings, Cronbach's alpha, CR and AVE, as presented in *Table 5*. To facilitate transparent evaluation of the hierarchical measurement model, indicator loadings for the first-order dimensions are reported alongside the reliability and validity statistics of the corresponding second-order constructs.

Several model refinements were undertaken to improve measurement adequacy while preserving theoretical coherence and construct content validity. Indicators with inadequate loading values (A5, A7, A8, C2 and C9) were removed based on statistical and conceptual considerations. Following reassessment of the measurement model, the psychological needs construct was excluded from the final model specification due to persistent discriminant validity concerns identified between psychological needs and extrinsic factors. Although construct combination was considered, the two constructs originated from different theoretical foundations and represented conceptually distinct domains. Combining them would have reduced theoretical clarity and weakened construct interpretability. The revised model was subsequently re-estimated and reassessed to confirm the adequacy of the retained measurement structure.

Several retained indicators exhibited loading values below the recommended threshold of 0.70, namely A4, A9, C1, C4, E1 and E4. Nevertheless, these indicators were retained because their removal did not result in meaningful improvements in CR or AVE. In addition, they represented conceptually important aspects of their respective dimensions and contributed to the content validity of the higher-order constructs. Retaining these indicators therefore ensured adequate construct coverage while preserving theoretically relevant content.

Cronbach's alpha values ranged from 0.766 to 0.930, CR values ranged from 0.865 to 0.954, and AVE values ranged from 0.681 to 0.878. All retained constructs exceeded the recommended thresholds for internal consistency reliability and convergent validity. Although several indicators demonstrated loadings below the preferred threshold, the overall reliability and validity statistics remained well above acceptable levels, supporting the adequacy of the retained measurement model.

Collectively, the results provide adequate evidence of convergent validity and internal consistency reliability for all retained constructs. The measurement model was therefore considered suitable for subsequent structural model evaluation.

TABLE 4. JOB SATISFACTION LEVELS

Category	Score range	Frequency	Percentage (%)
Very high	33.60–40.00	60	14.4
High	28.40–33.59	74	17.7
Moderate	23.20–28.39	85	20.3
Low	18.00–23.19	169	40.4
Very low	8.00–17.99	30	7.2
Total		418	100.0

TABLE 5. OUTER LOADINGS, CONVERGENT VALIDITY AND RELIABILITY

Construct	Item	Loading	Cronbach's alpha	CR	AVE
Plantation mechanisation (Usefulness)	A1	0.849	0.811	0.913	0.838
	A2	0.825			
	A3	0.745			
	A4	0.681			
	A6	0.759			
Plantation mechanisation (Ease of use)	A9	0.650			
	A10	0.917			
Intrinsic factors (Achievement)	B1	0.910	0.861	0.911	0.781
	B2	0.907			
Intrinsic factors (Growth)	B3	0.903			
	B4	0.908			
Intrinsic factors (Recognition)	B5	0.924			
	B6	0.923			
Extrinsic factors (Working conditions)	C1	0.657	0.766	0.865	0.681
	C3	0.815			
	C4	0.655			
	C5	0.806			
	C6	0.771			
	C7	0.800			
	C8	0.843			
Extrinsic factors (Job security)	C10	0.921			
	C11	0.936			
Extrinsic factors (Salary)	C12	0.954			
	C13	0.952			
Job satisfaction (Fulfilment)	E1	0.602	0.930	0.954	0.878
	E2	0.809			
	E3	0.701			
Job satisfaction (Attitudinal inclination to stay)	E4	0.561			
	E5	0.966			
	E6	0.961			
Job satisfaction (Emotional attachment)	E7	0.967			
	E8	0.965			

Note: CR - composite reliability; AVE - average variance extracted.

Discriminant Validity

Discriminant validity was assessed using the HTMT (Franke & Sarstedt, 2019; Henseler et al., 2015), as presented in Table 6. HTMT values ranged from 0.546 to 0.943. The highest value was observed between extrinsic factors and intrinsic factors (0.943), whereas all remaining values were below the recommended threshold of 0.90.

The Fornell-Larcker criterion was subsequently examined, as presented in Table 7. The results indicate that the square root of the AVE for each construct exceeded its correlations with all other constructs. This demonstrates that each construct shared more variance with its own indicators than with other constructs, supporting construct distinctiveness.

Additional evidence was obtained through HTMT inference using bootstrap confidence intervals. For the relationship between extrinsic factors and intrinsic factors, the 95% confidence interval ranged from 0.898 to 0.987. As the upper confidence limit remained below the critical value of 1.00, the interval did not include unity, providing further support for the distinction between the two constructs.

Although the HTMT value between extrinsic factors and intrinsic factors exceeded the conservative threshold of 0.90, both constructs remain theoretically distinct within Herzberg's Two-Factor Theory. Intrinsic factors reflect achievement, growth, and recognition, whereas extrinsic factors represent working conditions, job security, and salary. While both dimensions

contribute to employees' overall evaluation of their work environment, they capture different aspects of job satisfaction and therefore represent conceptually distinct domains.

Overall, the combined evidence from the HTMT assessment, HTMT inference, and Fornell-Larcker criterion supports the discriminant validity of the retained constructs. Despite the relatively strong association between intrinsic factors and extrinsic factors, the statistical results and theoretical distinction between the constructs justify their retention as separate constructs within the measurement model.

Structural Model Results and Integrated Discussion

The structural model results are presented in Table 8. The analysis examined the hypothesised relationships between plantation mechanisation, intrinsic factors, extrinsic factors, and job satisfaction. The significance and practical relevance of the proposed relationships were evaluated using path coefficients (β), t -values, p -values, and effect sizes (f^2). Collectively, these results provide empirical evidence for assessing the relative contribution of each predictor to job satisfaction among local machine operators in mechanised oil palm estates.

Model Explanatory Power and Effect Size

The structural model demonstrated moderate explanatory power, explaining 37.2% of the variance in job satisfaction ($R^2 = 0.372$; adjusted $R^2 = 0.367$). These findings indicate that plantation mechanisation, intrinsic factors, and extrinsic factors collectively explained a meaningful proportion of variation in job satisfaction among local machine operators. At the same time, the unexplained variance suggests that additional organisational, operational, or individual factors may also contribute to employees' overall evaluations of their work.

The effect size analysis further indicates that extrinsic factors exerted the greatest practical influence on job satisfaction ($f^2 = 0.077$), followed by plantation mechanisation ($f^2 = 0.046$), whereas intrinsic factors contributed only negligibly ($f^2 = 0.003$). Although the observed effect sizes are classified as small, they demonstrate that employment conditions and technological experiences contribute meaningfully to employees' work evaluations within mechanised plantation environments. Nevertheless, small effect sizes are commonly observed in organisational and behavioural research because employee attitudes are typically influenced by multiple interrelated factors. Accordingly, statistically significant

TABLE 6. HETEROTRAIT-MONOTRAIT (HTMT)

Construct	Extrinsic factors	Intrinsic factors	Job satisfaction	Plantation mechanisation
Extrinsic factors	–			
Intrinsic factors	0.943	–		
Job satisfaction	0.659	0.546	–	
Plantation mechanisation	0.851	0.847	0.589	–

TABLE 7. FORNELL-LARCKER CRITERION

Construct	Extrinsic factors	Intrinsic factors	Job satisfaction	Plantation mechanisation
Extrinsic factors	0.825			
Intrinsic factors	0.767	0.884		
Job satisfaction	0.574	0.517	0.935	
Plantation mechanisation	0.665	0.704	0.533	0.916

TABLE 8. STRUCTURAL MODEL RESULTS

Path	Coefficient (β)	t -value	p -value	f^2	Effect interpretation	Result
Extrinsic factors → Job satisfaction	0.356	5.740	<0.001	0.077	Small effect	Supported
Intrinsic factors → Job satisfaction	0.069	1.071	0.284	0.003	Negligible effect	Not supported
Plantation mechanisation → Job satisfaction	0.248	4.045	<0.001	0.046	Small effect	Supported

Note: f^2 - effect sizes.

relationships may still possess meaningful practical relevance despite relatively modest effect sizes.

Structural Relationships

Among the three predictors, extrinsic factors emerged as the strongest determinant of job satisfaction ($\beta = 0.356$, $t = 5.740$, $p < 0.001$). This finding suggests that favourable working conditions, employment security, and remuneration play a more influential role in shaping operators' work evaluations than the other factors examined in the model. Within mechanised plantation environments, employees appear to place considerable importance on stable employment arrangements and organisational support that enable them to perform their work effectively. This finding is consistent with Herzberg's Two-Factor Theory, which proposes that contextual employment conditions constitute an important foundation for employee satisfaction.

Plantation mechanisation also demonstrated a significant positive relationship with job satisfaction ($\beta = 0.248$, $t = 4.045$, $p < 0.001$). Operators who perceived machinery as useful and easy to use reported more favourable evaluations of their work, indicating that positive technological experiences contribute directly to overall job satisfaction. These findings support the TAM by demonstrating that technology-related evaluations extend beyond technology acceptance itself and remain relevant in shaping employees' broader evaluations of their work. In machine-dependent plantation environments, machinery forms an integral component of daily work activities, making technological experiences inseparable from employees' overall work experiences.

In contrast, intrinsic factors did not exert a significant influence on job satisfaction ($\beta = 0.069$, $t = 1.071$, $p = 0.284$). Although respondents generally reported favourable perceptions of achievement, growth, and recognition, these factors did not explain additional variation in job satisfaction after technological perceptions and employment conditions were considered simultaneously. This finding suggests that operators place greater emphasis on the practical conditions under which work is performed, including reliable machinery, organisational support, and employment stability, than on traditional intrinsic sources of motivation. Such a pattern is understandable within mechanised plantation operations, where effective task performance depends heavily on equipment availability, operational continuity and supportive organisational conditions.

Overall, the structural model indicates that job satisfaction among local machine operators is influenced primarily by employment conditions

and technological experiences rather than intrinsic motivational factors. Together, these findings support the complementary application of Herzberg's Two-Factor Theory and the TAM by demonstrating that employment conditions and technology-related evaluations jointly shape employees' overall work evaluations within mechanised plantation environments.

Theoretical and Practical Contributions

The findings contribute to plantation workforce research by extending existing studies beyond labour productivity, technology adoption, and operational performance to explain the factors shaping job satisfaction among local machine operators. More specifically, the study demonstrates that technological perceptions and employment conditions should be viewed as complementary rather than independent influences when examining workforce experiences in mechanised plantation environments. By integrating the TAM and Herzberg's Two-Factor Theory, the study extends the application of both theories to a machine-dependent occupational context and demonstrates their combined explanatory value in understanding job satisfaction. The findings further suggest that the influence of mechanisation extends beyond improving operational efficiency to shaping employees' overall evaluations of their work. This finding reinforces the importance of considering technological experiences as part of broader workforce evaluations rather than limiting mechanisation research to operational outcomes alone.

From a practical perspective, the findings indicate that investments in mechanisation alone may be insufficient to strengthen workforce satisfaction. Instead, the benefits of mechanisation are more likely to be realised when technological improvements are accompanied by supportive employment conditions, including reliable machinery, responsive maintenance systems, employment stability and adequate organisational support. Such an integrated approach is likely to enhance both employee satisfaction and the long-term sustainability of mechanised plantation operations.

CONCLUSION

This study examined the factors shaping job satisfaction among local machine operators in Malaysia's mechanised oil palm estates using an integrated framework comprising plantation mechanisation, intrinsic factors and extrinsic factors. The findings indicate that plantation mechanisation and extrinsic factors exert significant

positive effects on job satisfaction, whereas intrinsic factors do not demonstrate a significant influence within the proposed model. The structural model explained 37.2% of the variance in job satisfaction, indicating that technological perceptions and employment conditions account for a meaningful proportion of workforce evaluations within mechanised plantation environments.

The findings support the complementary application of the TAM and Herzberg's Two-Factor Theory in explaining job satisfaction among machine-dependent workers. Extrinsic Factors emerged as the strongest predictor of job satisfaction, followed by plantation mechanisation, highlighting the importance of favourable working conditions, employment stability, remuneration, and positive technological experiences in shaping operators' evaluations of their work. In contrast, intrinsic factors did not contribute significantly when technological perceptions and employment conditions were considered simultaneously, suggesting that operators place greater emphasis on the practical conditions under which work is performed than on traditional intrinsic sources of motivation, such as achievement, growth and recognition.

The study contributes to plantation workforce research by demonstrating that technological perceptions and employment conditions should be understood as complementary influences on job satisfaction rather than as separate explanatory domains. By integrating the TAM and Herzberg's Two-Factor Theory within a single analytical framework, the study extends the application of both theories to machine-dependent plantation work and provides empirical evidence from Malaysia's mechanised oil palm estates, a context that remains underrepresented in the literature. More importantly, the findings suggest that mechanisation influences not only operational performance but also employees' evaluations of their work, thereby broadening current understanding of workforce experiences within mechanised plantation environments.

From a practical perspective, the findings indicate that investments in mechanisation should be complemented by supportive employment conditions to maximise workforce satisfaction. Estate managers should therefore prioritise machinery reliability, responsive maintenance systems, employment stability, adequate remuneration and supportive workplace practices to ensure that the operational benefits of mechanisation translate into positive workforce experiences. Integrating technological investment with effective employment practices is therefore likely to strengthen employee satisfaction while supporting the long-term sustainability of mechanised plantation operations.

Several limitations should be acknowledged. First, the cross-sectional design restricts causal interpretation because all variables were measured at a single point in time. Accordingly, the findings should be interpreted as associative rather than causal despite the theoretically specified directions of the proposed relationships. Second, the reliance on self-reported responses may introduce common method bias. Third, because participation in the online survey was voluntary, the possibility of self-selection bias cannot be entirely excluded. Finally, the focus on local machine operators within Malaysian mechanised oil palm estates may limit the generalisability of the findings to other occupational groups, plantation systems, or national contexts.

Future research should adopt longitudinal research designs to examine how job satisfaction evolves as mechanisation practices and employment conditions change over time. Future studies may also investigate different categories of machine operators and incorporate additional organisational and operational variables, such as supervisory support, workload demands, technological upgrades, maintenance practices and leadership factors, to develop a more comprehensive understanding of workforce experiences within mechanised plantation environments.

Overall, this study demonstrates that the effectiveness of mechanisation should be evaluated not only in terms of operational efficiency and productivity but also through its influence on employees' work experiences. Ultimately, sustainable mechanised plantation operations depend not only on technological capability but also on creating employment conditions that enable machine operators to perform their work effectively and evaluate their work positively.

ACKNOWLEDGEMENT

This article is partly derived from a doctoral thesis submitted to Universiti Teknologi MARA (UiTM), Malaysia. The authors gratefully acknowledge the participating estates and local machine operators for their cooperation and support throughout the data collection process.

REFERENCES

- Baur, P., & Iles, A. (2023). Inserting machines, displacing people: How automation imaginaries for agriculture promise 'liberation' from the industrialized farm. *Agriculture and Human Values*, 40(3), 815–833. <https://doi.org/10.1007/s10460-023-10435-5>

- Boone, H. N., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension*, 50(2), 48. <https://doi.org/10.34068/joe.50.02.48>
- Crowley, M. Z. (2020). Foreign labour shortages in the Malaysian palm oil industry: Impacts and recommendations. *Asian Journal of Agriculture and Development*, 17(2), 1–18. <https://doi.org/10.37801/ajad2020.17.2.1>
- Daum, T. (2023). Mechanization and sustainable agri-food system transformation in the Global South: A review. *Agronomy for Sustainable Development*, 43, 16. <https://doi.org/10.1007/s13593-023-00868-x>
- Davidescu, A. A., Apostu, S.-A., Paul, A., & Casuneanu, I. (2020). Work flexibility, job satisfaction, and job performance among Romanian employees: Implications for sustainable human resource management. *Sustainability*, 12(15), 6086. <https://doi.org/10.3390/su12156086>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35(8), 982–1003. <https://doi.org/10.1287/mnsc.35.8.982>
- Economic Planning Unit. (2021). *Twelfth Malaysia Plan, 2021–2025: A prosperous, inclusive, sustainable Malaysia*. Prime Minister's Department. <https://rmke12.ekonomi.gov.my/en>
- Fletcher, L., Alfes, K., & Robinson, D. (2018). The relationship between perceived training and development and employee retention: The mediating role of work attitudes. *The International Journal of Human Resource Management*, 29(18), 2701–2728. <https://doi.org/10.1080/09585192.2016.1262888>
- Franke, G., & Sarstedt, M. (2019). Heuristics versus statistics in discriminant validity testing: A comparison of four procedures. *Internet Research*, 29(3), 430–447. <https://doi.org/10.1108/IntR-12-2017-0515>
- Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2–24. <https://doi.org/10.1108/EBR-11-2018-0203>
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modelling. *Journal of the Academy of Marketing Science*, 43(1), 115–135. <https://doi.org/10.1007/s11747-014-0403-8>
- Herzberg, F., Mausner, B., & Snyderman, B. B. (1959). *The motivation to work* (2nd ed.). John Wiley.
- Hobbs, M., Klachky, E., & Cooper, M. (2020). Job satisfaction assessments of agricultural workers help employers improve the work environment and reduce turnover. *California Agriculture*, 74(1), 30–39. <https://doi.org/10.3733/ca.2020a0002>
- Ismail, M., Alimin, N. S. N., & Bathaei, A. (2024). Improving the quality and productivity of palm oil through mechanisation in palm oil companies. *International Journal of Industrial Management*, 18(4), 212–222. <https://doi.org/10.15282/ijim.18.4.2024.11687>
- Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *Current Journal of Applied Science and Technology*, 7(4), 396–403. <https://doi.org/10.9734/BJAST/2015/14975>
- Kamaruddin, R., Abdullah, N., & Ayob, M. A. (2018). Determinants of job satisfaction among Malaysian youth working in the oil palm plantation sector. *Journal of Agribusiness in Developing and Emerging Economies*, 8(4), 678–692. <https://doi.org/10.1108/JADEE-06-2017-0063>
- Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, 22(140), 1–55.
- Mohiddin, A., Norhajjah, D., & El Pebrian, D. (2021). Exploring mechanization degree and capacity in Malaysia's oil palm plantations. *Agricultural Engineering International: CIGR Journal*, 23(2), 220–228.
- Nafea, N. M. M., Khayal, O. M. E. S., & Mohammed, K. A. M. A. (2025). Impact of human errors on maintenance performance in Atbara flour mill factories. *Excellence Journal for Engineering Sciences*, 2(1), 32–53.
- Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). McGraw-Hill.
- Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: A critical review

- of the literature and recommended remedies. *Journal of Applied Psychology*, 88(5), 879–903. <https://doi.org/10.1037/0021-9010.88.5.879>
- Ramli, A. S., Bakri, M. A. M., Ahmad, M. R., Mustafa, N. K., Khalid, M. R. M., & Azaman, I. H. (2023). Performance comparison of harvesting methods in oil palm plantations. *Advances in Agricultural and Food Research Journal*, 4(2), a0000410. <https://doi.org/10.36877/aafjr.a0000410>
- Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill-building approach* (7th ed.). Wiley.
- Shahiri, H., & Du, Y. (2025). Palm oil plantation workers in Malaysia and Indonesia: Issues and challenges. In N. Khalid, N. A. Abdul Rahman, C. W. Yan, & Z. Idris (Eds.), *The palm oil export market: Trends, challenges, and future strategies for sustainability* (1st ed., pp. 52–64). Routledge.
- Spector, P. E. (1997). *Job satisfaction: Application, assessment, causes, and consequences*. Sage Publications. <https://doi.org/10.4135/9781452231549>
- Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics* (7th ed.). Pearson.
- Thaddeus, D. J., Bakri, M. A. M., Khalid, M. R. M., Ahmad, M. R., Azaman, M. I. H., Mustafa, N. K., & Ramli, A. S. (2023). An overview of the benefits and advantages of implementing mechanisation in the oil palm plantation: A look at fresh fruit bunch (FFB) evacuation. *Advances in Agricultural and Food Research Journal*, 4(2), 6. <https://doi.org/10.36877/aafjr.a0000411>
- Weiss, D. J., Dawis, R. V., England, G. W., & Lofquist, L. H. (1967). *Manual for the Minnesota satisfaction questionnaire* (Minnesota Studies in Vocational Rehabilitation No. 22). Industrial Relations Center, University of Minnesota.
- Zapata-Hernández, A., Ruiz-Álvarez, E., Arias, N., Mosquera-Montoya, M., & Cooman, A. (2024). Adoption of mechanisation alternatives in oil palm crops in the Colombian Orinoquía natural region. *OCL*, 31, 10. <https://doi.org/10.1051/ocl/2024008>
- Zulkefli, F., Syahlan, S., Bakar, M. A., Khalid, M. F., & Rakibe, I. (2020). Factors influencing labour productivity in oil palm estate. *International Journal of Academic Research in Business and Social Sciences*, 10(4), 119–131. <https://doi.org/10.6007/IJARBS/V10-I4/7114>

MALAYSIAN PALM OIL SECTOR DURING THE ISRAEL AND UNITED STATES-IRAN CONFLICT (FEBRUARY–APRIL 2026): A CONTENT ANALYSIS APPROACH OF THE MEDIA FRAMING

AMIRUL AFIF MUHAMAT^{1*}; ADIBAH ALAWIAH OSMAN¹; MOHAMAD NIZAM JAAFAR²;
SRI REZEKI³ and NORZITAH ABDUL KARIM¹

ABSTRACT

This study examines media narratives on the Malaysian palm oil industry published from 28 February to 20 April 2026 during the intensified conflict involving the United States (US), Israel, and Iran. The study identified five main themes through an assessment of 487 news articles, editorials, and opinion pieces published in English and Malay by private and government-linked media organisations. The study used a structured coding framework to assess the themes, and the findings revealed statistics such as economic implications (43.1%), political stance (27.7%), national security (16.4%), sustainability impact (8.6%) and humanitarian aspect (4.1%). Government-linked media houses often depict stability and assure the public that the situation is under control and the government is working on the issue. The language affiliated/used by media houses also showed slight differences, with the English media focused more on financial analysis and global market trends, while the Malay media outlets discussed more about community concerns such as food security, livelihoods, and national sovereignty. Overall, the media portrayed palm oil as an essential national commodity that contributes significantly to the nation, despite trade disruptions caused by the conflict. This study informs readers how media capture and narrate news in ways that may influence society at large. Therefore, managing communication is as important as devising financial and business strategies in this critical era.

Keywords: commodity markets, content analysis, geopolitical conflict, media framing, palm oil.

Received: 11 May 2026; **Accepted:** 8 September 2026; **Published online:** 23 September 2026.

INTRODUCTION

As the world's second-largest palm oil producer, Malaysia relies heavily on the commodity

for many communities' livelihoods and for its contribution to the country's Gross Domestic Product (GDP) (Wulandari & Sholihin, 2026). Therefore, the country is vulnerable to economic shocks in any part of the world (Alatas, 2021; Nesadurai, 2025). Geopolitical tensions and conflicts, even when geographically distant from Malaysia, can still produce ripple effects. Hence, these elements are captured and discussed frequently in various platforms of media discourse (Chi et al., 2025). When the article was written, the conflict between Israel and the US versus Iran was still ongoing, albeit in a ceasefire situation. The escalation reached its peak between February and April 2026, when Iran closed the Strait of

¹ Climate Risk and Sustainable Finance RIG, Faculty of Business & Management, Universiti Teknologi MARA, 42300 Puncak Alam, Selangor, Malaysia.

² Arshad Ayub Graduate Business School, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

³ Faculty of Economics, Universitas Negeri Medan, Jalan William Iskandar Pasar V, Barat Medan Estate, North Sumatra 20221, Indonesia.

* Corresponding author e-mail: amirulafif@uitm.edu.my

Hormuz. As a result, serious disruptions affected international supply chains and energy prices. This caused price volatility and uncertainty for commodities such as palm oil, leading to various economic and social perceptions and operational reaction to the commodity-dependent nations (Prayoga et al., 2024).

Previous studies have examined the economic and political importance of palm oil, as well as media framing exercises due to geopolitical tensions (Nesadurai, 2025; Zaklama, 2025). However, the media portrayal of the country's palm oil sector is rarely discussed (Müller-Bloch & Kranz, 2015).

Originating from the Media Framing Theory, through the framing process (Almakaty, 2025), a better understanding of the geopolitical context by the public, government, and market participants can be achieved and better policy can be formulated (Chin, 2022). Moreover, industry stakeholders will gain insights into managing international trade risk, particularly in the palm oil industry, despite the global turmoil (Marshelli & Suyanto, 2025; Sokhatskyi et al., 2025).

Media Framing Theory

Media framing theory explains the media's ability to shape opinions about a particular issue and generate support for a journalist's intended purpose (Almakaty, 2025; Nuraini et al., 2024; Zaklama, 2025). Framing highlights certain aspects of a perceived situation and subsequently shapes views of the problem, moral judgement, and decision-making (Marshelli & Suyanto, 2025; Zaklama, 2025). Media framing or written narratives, encompasses various spectrums of readers' or audiences' opinions, including narratives and rhetorical content, as well as empirical evidence based on current events (Haj Omar, 2019; Iqbal & Farukh, 2025). Relevant examples can be derived from reports on the current conflict, which the media can project or frame as either getting worse, calmer or de-escalating (Doufesh & Briel, 2021; Nie & Zawawi, 2023). Interestingly, managing the media framing in the context of the commodity market is essential to understanding public and market participants' perceptions and for policy formulation during geopolitical conflict (Chumikov, 2025; Macnamara, 2005).

Media literacy is therefore an important skill, especially for authorities seeking to reduce bias and minimise implications for stakeholders (Ajetunmobi, 2023; Msughter et al., 2023). Therefore, for Malaysia's palm oil sector, it requires the nation to formulate policies and actions that protect the palm oil's interests (Alatas, 2021; Chin, 2022). Thus, this study emphasises journalists'

and media organisations' capacity to interpret and contextualise global events, translating distant conflicts into local relevance and contributing to public and policy reactions (Van den Bulck et al., 2019; Zaklama, 2025).

Conflict and Commodity Markets

Geopolitical conflicts introduce significant volatility and uncertainty into global commodity markets (Nassar, 2024; Zeng, 2024). Chi et al. (2025) concurred that geopolitical crises often disrupt supply chains, generate negative sentiment in capital markets, and alter global demand and supply for commodities, products and services (Chi et al., 2025; Nassar, 2024). The coalition of Israel-US versus Iran conflict, for example, affects oil prices and shipping routes, which in turn influence production and transport costs for other commodities such as palm oil (Chi et al., 2025). Muhamat et al. (2025) compare the situation to the tariff revision imposed by the US on many countries on the pretext of correcting the trade imbalance between the US and them. Nevertheless, the current conflict is worse, as it affects various levels of the supply chain due to serious impacts on global energy, particularly fuel and natural gas production and distribution (Popova, 2020). Likewise, uncertainty that exists due to the situation produces psychological and speculative dilemmas that often causes the commodities' prices, such as palm oil, to be perceived as higher than the actual prices that would otherwise prevail. The news reported by the media has strong potential to either mitigate or amplify the effects according to public perspectives, especially investors (Andini et al., 2025; Macnamara, 2005).

Research Gap and Conceptual Focus

Although considerable research has been conducted on Malaysia's palm oil sector, media framing, and the impact of geopolitical conflicts on commodity markets, a distinct research gap remains (Bulteel et al., 2021; Müller-Bloch & Kranz, 2015). These areas are frequently examined independently (*Figure 1*). For example, while some studies assess the economic and geopolitical relevance of palm oil, few examine how specific international conflicts, such as tensions between Israel and the US against Iran, influence Malaysian media coverage of palm oil (Alatas, 2021; Nesadurai, 2025). Similarly, research on media framing during conflicts generally focuses on the principal parties or directly affected regions, often neglecting the indirect consequences for commodity-producing countries and their major exports (Doufesh & Briel, 2021; Marshelli & Suyanto, 2025).

THE NEXUS OF GEOPOLITICS, MEDIA, AND MARKETS

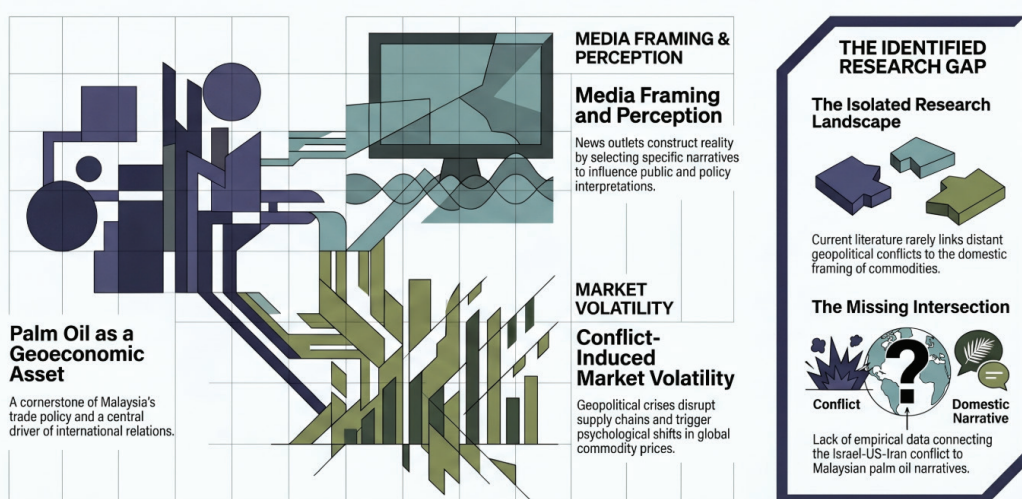


Figure 1. Summary of previous literature and research gap.

While content analysis is a prevalent method in media studies, it is infrequently used to explore how rare geopolitical conflicts shape domestic discussions of nations such as Malaysian palm oil (Sjøvaag & Stavelin, 2012). This study aims to address this gap by directly connecting Malaysia's palm oil sector to media framing arising from the Israel-US versus Iran conflict, thereby offering a novel empirical contribution.

MATERIALS AND METHOD

The study adopts a qualitative content analysis approach, supported by descriptive frequency counts to systematically examine Malaysian media's portrayal of the palm oil sector during the Israel-US versus Iran conflict (Manoilo & Strigunov, 2019; Rouhi, 2018). This method enables a detailed interpretive exploration of communication content by identifying nuanced meanings, themes, and framing strategies within the selected media texts (Frasetya et al., 2025).

Specification of media outlets and sampling frame deployed a purposive sampling strategy in a bid to capture a wide range of the media landscape in Malaysia based on two main variables: (1) language (English vs. Malay) and (2) media ownership (government-linked vs. private). The final data collection of 487 samples was accomplished within the stipulated 8-week period between 28 February and 20 April 2026. The media outlets sampled were primary English-language media (The Star and The New Straits Times, and the major online portals such as The Edge). While the Malay language media included Utusan Malaysia, Bernama, Sinar Harian and Harian Metro.

Furthermore, the inclusion criteria are individual news reports and articles or editorials and opinion pieces, written on the Malaysian palm oil sector and the 2026 Israel-US-Iran conflict, which were identified manually. Meanwhile, the exclusion criteria are coverage of the Middle East conflict that does not refer to or include palm oil, or routine domestic palm oil news that does not address or include the conflict.

The specific period of analysis spans from 28 February to 20 April 2026, capturing the height of the conflict (when it started). This qualitative approach prioritises understanding the contextual and rhetorical dimensions of media representation, moving beyond mere frequency counts to interpret how narratives are constructed and reinforced (Odoemelum & Hasan, 2021).

Sampling

This study used qualitative content analysis to systematically examine how Malaysian media portrayed the palm oil sector during the Israel-US versus Iran conflict (Manoilo & Strigunov, 2019; Rouhi, 2018). This approach offers a detailed, interpretive look at communication content, helping identify subtle meanings, themes, and framing strategies in the selected media texts (Frasetya et al., 2025). The analysis focuses on the period from 28 February to 20 April 2026, which marks the height of the geopolitical tensions. By using this qualitative method, the study aims to explain the contextual and rhetorical aspects of media representation, going beyond simple frequency counts to interpret how narratives are constructed and reinforced (Odoemelum & Hasan, 2021).

Unit of Analysis

This content analysis used individual news articles, editorials, and opinion pieces as the main units of analysis (Hasyim et al., 2025). Only items that mentioned Malaysia's palm oil sector in connection with the Israel-US versus Iran conflict were included. The reviewed content discussed the conflict's broader economic impact, changes in global commodity markets, or specific issues such as palm oil exports, production, or industry views during periods of international instability. Each media item was coded separately to allow for a detailed look at framing, narrative, and themes (Odoemelum & Hasan, 2021). News or articles that only discussed the conflict without mentioning palm oil or focused on palm oil without linking it to the conflict, were excluded (Karlsson & Sjøvaag, 2016).

Coding Framework

We created a coding framework to identify and organise framing elements in the media content we sampled. The main categories are: (1) Economic implication, which covers references to price changes, export volumes, trade routes, supply chain issues, and financial effects on the industry or national economy. (2) Political stance, which includes statements about government policy, international relations, trade diplomacy, national sovereignty, or alliances in response to the conflict. (3) Sustainability discourse, discussions about the environmental or social aspects of palm oil, especially when linked to conflicts or international perspectives. (4) National security, includes discussions of food and energy security, as well as the strategic role of palm oil in maintaining the country's stability during times of geopolitical tension. Lastly, (5) Geopolitical context, covers broader discussions that link palm oil to regional

or international power dynamics shaped by the conflict. Each category has sub-codes to add detail and help capture the full range of framing nuances (Frasetya et al., 2025).

Reliability

To enhance trustworthiness, we implemented intercoder reliability procedures. Approximately 10% of the items were independently coded using the same framework and decision rules. Coding discrepancies were discussed and resolved, leading to updates to the codebook. Cohen's kappa was then calculated to assess agreement; values greater than 0.80 indicate strong reliability. Trustworthiness was further strengthened by clearly defining categories and consistently applying inclusion criteria. These procedures ensure that observed differences across outlets reflect genuine variations in framing rather than selection artefacts. *Table 1* demonstrates the steps of the reliability framework.

Limitations

This study acknowledges several methodological limitations, while noting that they do not undermine the reliability of the findings. Although the chosen timeframe, 28 February to 20 April 2026, was relatively brief, it captured critical aspects of the conflict at its most intense stage. Having said that, the study does not indicate whether changes happened in the long run (Müller-Bloch & Kranz, 2015). To reiterate, that is not the aim of this study.

Furthermore, the selected news outlets represent a relatively small sample, although they cover mainstream media outlets. In terms of concerns, some of the news sentiments in other languages such as Mandarin and Tamil were not selected due to our inability to comprehend the languages. Also, since the data was analysed manually instead of

TABLE 1. STEPS OF RELIABILITY FRAMEWORK

No.	Methodological dimension	Operational Steps	References
1.	Media Content Analysis	Systematic textual breakdown	Sjøvaag & Stavelin (2012) discussed the validation of digital and print media.
2.	Dual-Coder Framework	2 Coders	Akhmedov et al. (2021) provided dual-coding procedures for the categorisation of media content
3.	Pilot Sample Size	n = 49% (10.06%)	Frasetya et al. (2025) suggested 10% as the standard empirical benchmark for pilot reliability testing in communication research.
4.	Discrepancy Resolution	Negotiated Consensus	Odoemelum & Hasan (2021) discussed the negotiated agreement to refine coding categories and remove coder drift.
5.	Intercoder Dimension	K = 0.85% (minimum 0.80%)	Landis & Koch (1977) referred to Cohen (1960) on K > 0.80% as the standard for substantial/almost perfect intercoder agreement.

using software or system, there is a possibility of error; however, this issue has been addressed by including two researchers to examine the data as per the dual-coder process. Nevertheless, this study has covered the essential media, which were in Malay (the national language) and English (a language that is widely spoken in the business sector).

RESULTS AND DISCUSSION

Descriptive Results

The findings show that media coverage from 28 February to 20 April 2026 channelled several themes concerning the palm oil sector in relation to the geopolitical conflict. Most media narratives focused on economic implications, political stance, national security, sustainability and humanitarian aspects (*Table 2*).

The economic implication narrative concerns palm oil price volatility caused by the conflict, logistical disruptions, and effects on palm oil export earnings (Chi et al., 2025; Nassar, 2024). Political stance frequently discusses the diplomatic steps taken by the government to safeguard the trading relationship while at the same time emphasising Malaysia's non-aligned stance (Chin, 2022). The security aspect derived from palm oil's earnings to Malaysia as an important commodity that is vulnerable to externalities (Bushuev, 2025).

Views Comparison

Media language affiliation, whether English or Malay, and ownership type, whether private or government-linked, were associated with different approaches. The English-language publication house, such as The Star, emphasises an international setting comprising market trend analysis, global diplomatic-economic impacts and practitioners' opinions on palm oil in the form of market indices and regional projections (Chi et al., 2025). In contrast, the Malay-language media such as Utusan Malaysia focused more on the Malaysians' social and economic effects of the conflict over palm oil. They highlighted issues facing smallholders such as lack of capital for replanting the old trees (SME Asia,

2025), crop diseases (Annuar, 2025) and extreme weather (Thompson et al., 2023), to name a few and concerns about national food security. These outlets often describe political actions in terms of national pride and sovereignty, linking government decisions to the protection of local livelihoods. Malay media used the national security frame more often, stressing the importance of palm oil for the country's stability and independence. Bernama, as one of the reputable government-affiliated outlets, often focused on the stability that the government has provided despite the challenges. The published news focused on the government's steps and formulated strategies to address the impacts brought by the conflict, and the reports often in the mood of pacification and calmness towards the pressures globally (Chin, 2022). Likewise, private media adopts more critical views of the strategies taken to safeguard the palm oil industry. It clearly denotes the differences in approach and targeted readers and listeners (Huang & Leung, 2005).

Narrative Patterns

Media coverage revealed several main narrative patterns that influenced how the public viewed Malaysia's palm oil sector during the conflict. One common narrative described palm oil as a "resilient commodity," able to withstand global challenges because of steady demand and Malaysia's strong market position. This view often emphasised the industry's ability to adapt and pointed to ongoing efforts to find new markets or improve product value (Alam et al., 2022; Nesadurai, 2025).

Another important narrative focused on palm oil's vulnerability to sanctions and trade disruptions. This perspective highlighted possible increases in shipping costs, insurance premiums, or direct trade restrictions as the conflict escalated (Chi et al., 2025). It often raised concerns about fragile global supply chains and how instability in the Middle East could indirectly affect commodity markets far away (Nassar, 2024).

A third strong narrative portrayed palm oil as a symbol of "national pride and economic sovereignty." This view often connected the industry to Malaysia's development successes and its ability to pursue an independent foreign policy

TABLE 2. REVIEWED FREQUENCY OF MEDIA FRAMES

Frame category	Frequency (n = 487 articles)	Percentage (%)
Economic implication	210	43.1
Political stance	135	27.7
National security	80	16.4
Sustainability impact	42	8.6
Humanitarian aspects	20	4.1

(Alatas, 2021). It emphasised how the industry adds to national wealth and helps Malaysia assert its economic independence internationally, especially when facing outside pressure or criticism.

These narratives often overlapped, showing the complex and sometimes conflicting challenges the industry faces. Media sources regularly balanced stories of resilience with warnings about vulnerability, while consistently stressing the importance of palm oil to Malaysia's national identity and economic stability.

Visual Aids

Media coverage often used visual aids like charts showing commodity price changes or maps of affected trade routes to reinforce key themes. For instance, line graphs comparing crude palm oil (CPO) prices with global oil benchmarks were frequently included to show the conflict's economic impact. These graphics appeared in articles about market volatility or inflation risks, making complex economic data easier for readers to understand (Chi et al., 2025).

Infographics showing where Malaysia exports palm oil or its production numbers highlighted the industry's global importance. Maps of major shipping routes, especially through the Strait of Hormuz and other critical points, made concerns about trade disruptions and national security more visible. Articles often included photos of Malaysian palm oil plantations or industry leaders, which supported the idea of national pride. These visuals played a key role in shaping how the stories were framed and how audiences understood them.

Contextualisation

Economic implications and political stance are the main themes in Malaysian media discussions of the palm oil sector during the Israel-US versus Iran conflict. By focusing on economic data, the media show a national concern for keeping stability in this important export industry, linking far-off geopolitical events to Malaysia's own economic health (Nassar, 2024). This matches earlier studies showing that geo-economic conflicts require flexible marketing strategies and risk management in global markets (Sokhatskyi et al., 2025). The analysis also shows that who owns the media and the language they use affects how these themes are presented. Government-linked media used certain frames to reassure people and emphasise national resilience. In contrast, private and Malay-language outlets focused more on local impacts and national identity (Huang & Leung, 2005). These differences highlight how state messaging, public interests, and various media goals interact to shape national stories during crises.

The idea of palm oil as a "resilient commodity" and a source of "national pride" helps boost confidence and shows strength in the face of external threats. These stories can reduce panic and encourage unity (Nie & Zawawi, 2023). On the other hand, the "vulnerable to sanctions" theme warns stakeholders of potential issues and underscores the need for proactive policies. In general, the media frames these issues strategically to shape opinions, protect economic interests, and strengthen national identity in a changing global context (Alatas, 2021).

CONCLUSION

In summary, this study examined media narratives on the impact of the intense conflict involving Israel, the US, and Iran on Malaysian palm oil from 28 February to 20 April 2026 (although the situation is now under a ceasefire while this article was written). Findings indicate that the media coverage focused on several themes, which are economic implications, political stance and national security. The media also emphasised the government's role in stabilising the commodity through trade diplomacy and framing geopolitical instability as an economic risk to palm oil. Moreover, palm oil is always depicted as a national strategic commodity and the differences between the English and Malay media outlets, as well as the private and government-linked media houses, have their own priorities in news reporting.

Earlier discussions have highlighted that media framing is essential for projecting the government's efforts during the current energy crisis and for pacifying the public about its side effects. Likewise, a specific assessment of palm oil in public perception showed that the narrative is that the palm oil supply is stable for the local market, albeit with challenges due to the high cost of fertiliser resulting from the closure of the Hormuz Strait. Another message being sent to the public is that demand for palm oil is increasing due to concerns in the traditional market.

This research suggests several directions for future study that can bring more useful findings for decision-making. In addition to the current research's scope, future studies can include other major palm oil producers, such as Indonesia or Thailand. Based on the same method, media coverage of the impacts on the two countries' palm oil sector due to the conflict between Israel and the US versus Iran can be framed. From the comparison, we can note the media influence on public opinion in those countries as well as their governments' strategies and intervention. Likewise, future research could also assess various groups in Malaysia, such as smallholders, big plantations, refineries and others, on their responses to the geopolitical conflict.

ACKNOWLEDGEMENT

We would like to express our appreciation to UiTM for continuous support for research activities, including this study. The figure were generated with the assistance of NotebookLM based on the authors' concepts and ideas. The authors take full responsibility for the final content and accuracy of the figure.

REFERENCES

- Ajetunmobi, U. O. (2023). Media framing and construction of socio-political issues in Nigeria: (Dis)connection between theory and professional ethics. *Mediterranean Journal of Social & Behavioral Research*, 7(2), 93–101. <https://doi.org/10.30935/mjosbr/13053>
- Akhmedov, R., Bezkorovainyi, V., & Danylchenko, T. (2021). Methodology of analysis of the content of electronic media. *Economic Space*, 176, 141–145. <https://doi.org/10.32782/2224-6282/176-25>
- Alam, M. K., Tabash, M. I., Billah, M., Kumar, S., & Anagreh, S. (2022). The impacts of the Russia-Ukraine invasion on global markets and commodities: A dynamic connectedness among G7 and BRIC markets. *Journal of Risk and Financial Management*, 15(8), 352. <https://doi.org/10.3390/jrfm15080352>
- Alatas, S. M. (2021). A Malaysian perspective on foreign policy and geopolitics: Rethinking West-centric international relations theory. *Global Studies Quarterly*, 1(4), 1–11. <https://doi.org/10.1093/isagsq/ksab031>
- Almakaty, S. (2025). A comprehensive and critical literature review on framing theory in the digital media age. *Preprints*. <https://doi.org/10.20944/preprints202504.1728.v1>
- Andini, Nuriyah, R. S., & Rahmadian, J. A. E. (2025). Framing agricultural media: An analysis of critical discourse of Business CNN and CNN Indonesia using Van Dijk's theory. *Pawarta: Journal of Communication and Da'wah*, 3(2), 67–74. <https://doi.org/10.54090/pawarta.832>
- Annuar, A. (2025, September 29). Smallholders drive Malaysia's palm oil supply chain resilience. *The Malaysian Reserve*. <https://themalaysianreserve.com/2025/09/29/smallholders-drive-malaysias-palm-oil-supply-chain-resilience/>
- Bulsteel, A. J. B., Larson, E. L., & Getahun, H. (2021). Identifying global research gaps to mitigate antimicrobial resistance: A scoping review. *American Journal of Infection Control*, 49(6), 818–824. <https://doi.org/10.1016/j.ajic.2020.11.024>
- Bushuev, E. S. (2025). International commodities market as an operational environment for geopolitical rivalry: Classification of goals and historical illustrations. *Eurasian Integration: Economics, Law, Politics*, 19(3), 148–157. (In Russian).
- Chi, X., Zheng, R., Chen, Y., & Xiao, G. (2025). Research on the volatility spillover effects of geopolitical conflict risks on international shipping and crude oil markets. *Frontiers in Marine Science*, 12, 1647599. <https://doi.org/10.3389/fmars.2025.1647599>
- Chin, K. F. (2022). Malaysia in changing geopolitical economy: Navigating great power competition between China and the United States. *The Chinese Economy*, 56(4), 321–329. <https://doi.org/10.1080/10971475.2022.2136697>
- Chumikov, A. N. (2025). Conflict theory in the socio-political sphere: Retrospective dynamics and modern vector of media communication impact. *Sociological Science and Social Practice*, 13(1), 95–116. <https://doi.org/10.19181/snsp.2025.13.1.5> (In Russian).
- Doufesh, B., & Briel, H. (2021). Ethnocentrism in conflict news coverage: A multimodal framing analysis of the 2018 Gaza protests in the Times of Israel and Al Jazeera. *International Journal of Communication*, 15, 4230–4251.
- Frasetya, V., Nasoetion, N. A., Pratama, P. A., & Rakhmadi, R. (2025). Communicating food security: A comparative framing analysis of three local media outlets in Lampung Province. *Lontar: Jurnal Ilmu Komunikasi*, 13(2), 489–497. <https://doi.org/10.30656/lontar.v13.i2.11394>
- Haj Omar, H. (2019). A narrative approach to media reporting of the Arab-Israeli conflict 2000–2010. *International Journal of Interpretation and Translation*, 17(1), 20–38. <https://doi.org/10.1075/forum.17014.haj>
- Hasyim, T., Kartika, Y., & Sari, R. A. (2025). Media construction of Enggano Island's isolation: A comparative framing analysis of detikcom and Kompas.com using Entman's model. *Priviet Social Sciences Journal*, 5(11), 400–411. <https://doi.org/10.55942/pssj.v5i11.965>
- Huang, Y., & Leung, C. C. M. (2005). Western-led press coverage of mainland China and Vietnam during the SARS crisis: Reassessing the

- concept of 'Media Representation of the Other'. *Asian Journal of Communication*, 15(3), 302–318. <https://doi.org/10.1080/01292980500261621>
- Iqbal, S., & Farukh, A. (2025). Framing narratives: Media representation of metaphors and ideologies in Israel-Palestine conflict. *Cogent Arts & Humanities*, 12(1), 2564883. <https://doi.org/10.1080/23311983.2025.2564883>
- Karlsson, M., & Sjøvaag, H. (2016). Content analysis and online news: Epistemologies of analysing the ephemeral web. *Digital Journalism*, 4(1), 177–192. <https://doi.org/10.1080/21670811.2015.1096619>
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174. <https://doi.org/10.2307/2529310>
- Macnamara, J. (2005). Media content analysis: Its uses, benefits and best practice methodology. *Asia Pacific Public Relations Journal*, 6(1), 1–34.
- Manoilo, A. & Strigunov, K. (2019). Geopolitical tensions over Iran in local, regional and global contexts. *Istoriya*, 10(11). <https://doi.org/10.18254/s207987840008089-6> (In Russian).
- Marshell, & Suyanto. (2025). Analisis framing pemberitaan konflik Hamas-Israel pada media online Kompas.com dan The New York Times [Framing analysis of the Hamas-Israel conflict news on online media Kompas.com and The New York Times]. *MEDIUM: Jurnal Ilmiah Fakultas Ilmu Komunikasi*, 13(1), 25–45. <https://doi.org/10.25299/medium.v13i1.20751>
- Msugther, A. E., Garba, S., & Rabi, A. B. (2023). Framing theory perspective of identity and narratives of conflict in Nigerian media. *Indian Journal of Mass Communication and Journalism*, 1(2), 1–5. <https://doi.org/10.54105/ijmcj.d1039.121221>
- Muhamat, A. A., Jaafar, M. N., Najid, N. A., Shafi, R. M., Abd Rashid, M. H., & Danarsari, D. N. (2025). United States tariff shockwaves: Malaysia's palm oil in the crosshairs. *Oil Palm Industry Economic Journal*, 25(2), 60–68. <https://doi.org/10.21894/opiej.2025.04>
- Müller-Bloch, C., & Kranz, J. (2015). A framework for rigorously identifying research gaps in qualitative literature reviews. In *Proceedings of the Thirty Sixth International Conference on Information Systems* (pp. 1–19).
- Nassar, I. (2024). Geopolitical turmoil and market dynamics: The impact of the Ukraine-Russia conflict on global commodities. *World Safety Journal*, 33(3), 1–14. <https://doi.org/10.5281/zenodo.13942858>
- Nesadurai, H. E. S. (2025). Malaysia's ambivalent middle power status: A global south perspective from a reconceptualised geoeconomics. *Global Policy*, 17(S1), S65–S74. <https://doi.org/10.1111/1758-5899.70072>
- Nie, K. S., & Zawawi, J. W. (2023). Systematic review of mediatization of politics in Southeast Asia. *Jurnal Komunikasi: Malaysian Journal of Communication*, 39(1), 294–308. <https://doi.org/10.17576/jkmjc-2023-3901-17>
- Nuraini, F. P., Mulyana, D., & Herawati, M. (2024). Framing analysis of Iran-Israel's 2024 conflict in Kompas.id, Aljazeera.com, and NYTimes.com. *Kajian Jurnalisme*, 8(1), 52–67. <https://doi.org/10.24198/jkj.v8i1.55562>
- Odoemela, C. E., & Hasan, N. N. N. (2021). Evaluating escalation in oil pollution and its framing: Approaches used by the print media for coverage. *Environmental Research Communications*, 3(11), 115010. <https://doi.org/10.1088/2515-7620/abdb7c>
- Popova, I. (2020). Geopolitical factors and their role in the development of the international oil market: A literature review. *International Organisations Research Journal*, 15(3), 282–306. (In Russian).
- Prayoga, R. D., Kurniawan, M. R., Abidin, A. Z., & Praswati, A. N. (2024). The impact of the Israeli-Palestinian geopolitical conflict on global financial markets. In K. Keni, H. K. Tunjungsari, & T. A. Ping (Eds.), *Proceedings of the Twelfth International Conference on Entrepreneurship and Business Management 2023* (pp. 119–127). Springer. https://doi.org/10.2991/978-94-6463-508-9_10
- Rouhi, M. (2018). US-Iran tensions and the oil factor. *Survival*, 60(5), 33–40. <https://doi.org/10.1080/00396338.2018.1518367>
- Sjøvaag, H., & Stavelin, E. (2012). Web media and the quantitative content analysis: Methodological challenges in measuring online news content. *Convergence: The International Journal of Research into New Media Technologies*, 18(2), 215–229. <https://doi.org/10.1177/1354856511429641>
- SME Asia. (2025, August 11). Low replanting rate threatens long-term palm oil productivity. *SME Magazine*. <https://sme.asia/low-replanting-rate-threatens-long-term-palm-oil-productivity/>

- Sokhatskyi, O., Hlukhyi, N., & Huryk, O. (2025). Geo-economic conflicts as a factor in the transformation of international marketing strategies. *Sciences of Europe*, 175, 80-84.
- Thompson, W. J., Varma, V., Joerin, J., Bonilla-Duarte, S., Bebbler, D. P., Blaser-Hart, W., Kopainsky, B., Späth, L., Curcio, B., Six, J., & Krütli, P. (2023). Smallholder farmer resilience to extreme weather events in a global food value chain. *Climatic Change*, 176(11), 152. <https://doi.org/10.1007/s10584-023-03586-1>
- Van den Bulck, H., Puppis, M., Donders, K., & Van Audenhove, L. (Eds.). (2019). *The Palgrave handbook of methods for media policy research*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-16065-4>
- Wulandari, W., & Sholihin, E. B. (2026, May 24). Malaysia's palm oil paradox. *East Asia Forum*. <https://eastasiaforum.org/2026/05/23/malaysias-palm-oil-paradox/>
- Zaklama, S. (2025). Exploring the foundations of media framing theory. *European Modern Studies Journal*, 9(1), 75–89. [https://doi.org/10.59573/emsj.9\(1\).2025.7](https://doi.org/10.59573/emsj.9(1).2025.7)
- Zeng, Z. (2024). The impact of the regional military conflict in global stock and commodity market. *SHS Web of Conferences*, 181, 02017. <https://doi.org/10.1051/shsconf/202418102017>



MPOB Press
Malaysian Palm Oil Board
6, Persiaran Institusi, Bandar Baru Bangi
43000 Kajang, Selangor, Malaysia
Tel: +603-8769 4400 | Fax: +603-8925 9446
E-mail: pub@mpob.gov.my



www.mpob.gov.my



Malaysian Palm Oil Board



[mpob_ig](#)



[MPOB_tweets](#)