Compiling a Lowe-Based Plasma FFB Price Index and Assessing Weight Structure Sensitivity

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ABSTRACT

Officially determined fresh fruit bunch (FFB) prices for plasma smallholders vary across provinces, motivating interprovincial monitoring. This study compiled a Lowe price index for 22 provinces during May 2025–September 2026 and assessed its sensitivity to five alternative weighting scenarios. Monthly provincial prices were arithmetic averages of available daily observations. May 2025 was the price reference period (index = 100), and 2024 crude palm oil (CPO) production from smallholder plantations served as a quantity proxy because plasma FFB production data were unavailable in the dataset. Mean Absolute Percentage Deviation (MAPD) measured differences in index values; Total Variation Distance (TVD) measured differences in provincial weight distributions. The index reached a low of 94.99 in June 2025, a high of 114.19 in April 2026, and 114.16 in September 2026, representing a 14.16% increase from May 2025. MAPD ranged from 0.0039% to 0.0846%, while TVD ranged from 0.46% to 4.99%. The study contributes an interprovincial indicator of officially determined plasma FFB price changes and evidence of limited sensitivity to the weighting scenarios examined. However, CPO-based weights may not represent the plasma FFB production structure, and the index does not measure actual transaction prices or smallholder income.

Keywords: fresh fruit bunch prices, Lowe index, oil palm smallholders, price index, sensitivity analysis

I. INTRODUCTION

Oil palm is one of Indonesia's most important plantation commodities, accounting for 83.37% of national plantation production and generating export earnings of USD 22.86 billion in 2024 (Kartawinata et al., 2026; Ministry of Agriculture of the Republic of Indonesia, 2025). Of the total national oil palm plantation area of 16.83 million hectares, approximately 40.29%, or 6.78 million hectares, is managed by smallholders, involving millions of households (Ministry of Agriculture of the Republic of Indonesia, 2025; Syahputra et al., 2024). Smallholder oil palm cultivation has been shown to improve household income, food security, and investment in human capital, including education and health, in rural areas (Chrisendo et al., 2022; Mehraban et al., 2021). However, average productivity among smallholder plantations remains lower than that of large private and state-owned plantations, partly reflecting technical inefficiencies and limited access to agronomic inputs (Abdul et al., 2022; Dalheimer et al., 2022; Woittiez et al., 2024). Lower physical productivity can constrain farmers' profit margins, making their economic well-being particularly vulnerable to fluctuations in fresh fruit bunch (FFB) prices at the farm level (Hendrawan et al., 2024; Reich et al., 2026; Varwasih et al., 2023).

Within the palm oil supply chain, smallholders may face limited bargaining power and asymmetric price transmission, as discussed in studies of the palm oil supply chain (Nesti et al., 2026; Zhafira et al., 2026). Furthermore, differences in smallholder partnership

status are associated with variations in FFB purchasing and pricing arrangements, including regulatory provisions governing purchase prices for partnered smallholders (Ministry of Agriculture of the Republic of Indonesia, 2025; Ruml et al., 2022; Syahputra et al., 2024).

Regulations governing FFB purchases from partnered smallholders were updated through Minister of Agriculture Regulation No. 13 of 2024 concerning the purchase of FFB produced by partnered oil palm smallholders (Ministry of Agriculture of the Republic of Indonesia, 2024). Under this regulation, FFB purchase prices are determined by the head of the relevant provincial agency on behalf of the governor, based on recommendations from the provincial price-setting team. The pricing mechanism considers the "K" index, crude palm oil (CPO) and palm kernel (PK) extraction rates, and the selling prices of CPO and PK. The price-setting team is required to meet at least once every two weeks (Ministry of Agriculture of the Republic of Indonesia, 2024).

Previous studies have examined FFB price integration with the CPO market (Varwasih et al., 2023), interregional price volatility and transmission (Herdiyanti et al., 2023), and national-level forecasting of FFB producer prices (Herdiyanti & Sukiyono, 2023). Although these studies provide insights into price relationships, volatility, and forecasting, they have not specifically addressed the compilation of an interprovincial index for monitoring relative changes in officially determined plasma FFB prices over time. Given that FFB prices are determined at the provincial level and production contributions differ across provinces, an aggregate price-monitoring indicator requires an appropriate weighting structure. Furthermore, the selection of the weighting structure and reference period may influence the resulting index values (Herzberg et al., 2023).

The compilation of an intertemporal price index requires a weighting structure that accounts for provincial production contributions. Weights based on production data from a single month may reflect temporary or seasonal production conditions. Therefore, annual production quantities can be considered to establish a weighting structure that encompasses production throughout an entire year (International Monetary Fund, 2004). When the weight reference period differs from the price reference period, the Lowe index allows quantities from the former period to serve as a fixed basket valued at prices from the respective periods.

Accordingly, this study compiles a Lowe price index of officially determined plasma FFB prices across 22 Indonesian provinces, using May 2025 as the price reference period and 2024 CPO production from smallholder plantations as a proxy for quantity weights. The study produces a monthly index series covering May 2025 to September 2026 and evaluates its sensitivity to five alternative weight reference periods. Mean Absolute Percentage Deviation (MAPD) is used to assess relative differences in index values, while Total Variation Distance (TVD) measures differences in provincial weight distributions. The empirical novelty of this study lies in compiling an interprovincial price index specifically for officially determined plasma FFB prices and evaluating its sensitivity to alternative weight reference periods. Thus, the study contributes a specifically defined price-monitoring indicator and empirical evidence on how different production-based weighting structures affect the resulting index.

II. RESEARCH METHODOLOGY

Data Types and Sources

This study used secondary data on officially determined fresh fruit bunch (FFB) prices for plasma smallholders with oil palms aged 10–20 years across 22 Indonesian provinces, namely Aceh, Banten, Bengkulu, Gorontalo, Jambi, West Kalimantan, South Kalimantan, Central Kalimantan, East Kalimantan, North Kalimantan, Bangka Belitung Islands, Lampung, Papua, West Papua, Riau, West Sulawesi, South Sulawesi, Central Sulawesi, Southeast Sulawesi, West Sumatra, South Sumatra, and North Sumatra. These 22

provinces were selected based on the availability of officially determined plasma FFB price data sourced from the Sistem Informasi Pasar Produk Perkebunan Unggulan (SIPASBUN), Asosiasi Petani Kelapa Sawit Indonesia (APKASINDO), and public reports from provincial plantation agencies (Dinas Perkebunan), as consolidated in the Indonesia Palm Oil Strategic Studies (IPOSS) database. Monthly observations were available for all included provinces throughout the index calculation period (May 2025–September 2026). Provincial FFB price data for December 2024–September 2026 were accessed through the IPOSS database. Annual crude palm oil (CPO) production data for smallholder plantations for 2022–2024 were obtained from the IPOSS database, while monthly CPO production data for May 2025 were sourced from Badan Pusat Statistik (BPS).

May 2025 was selected as the price reference period because it was the earliest month with available monthly price data for all 22 provinces. This period also followed the issuance of Minister of Agriculture Regulation No. 13 of 2024. Provincial FFB production data specifically for plasma smallholders were not available in the dataset used. Therefore, CPO production from smallholder plantations was employed as a quantity proxy, considering its direct production relationship with FFB and the availability of provincial production data. This proxy was used to approximate the relative scale of smallholder oil palm production across provinces rather than to represent actual plasma FFB quantities. Annual CPO production from smallholder plantations in 2024 was selected as the quantity proxy because it represented the most recent complete calendar year preceding the price reference period. The Lowe index accommodates the use of different reference periods for prices and quantities. However, smallholder CPO production does not represent the actual volume of FFB produced by plasma smallholders. Consequently, the resulting weighting structure may not fully represent the production structure of the population covered by the price data.

Table 1. Variables Used in the Study

Variable	Unit	Period	Source
Officially determined plasma FFB prices	Rp/kg	December 2024 to September 2026*	IPOSS Data
Annual smallholder CPO production by province	Tons	2022–2024**	IPOSS Data
Monthly smallholder CPO production by province	Tons	May 2025**	BPS

*= Price data for December 2024–April 2025 were used to evaluate the selection of the price reference period. The aggregate index was calculated for May 2025–September 2026.

**= CPO production data for 2022–2024 and May 2025 were used in the sensitivity analysis. The main specification used annual smallholder CPO production in 2024 as the quantity proxy.

Monthly Price Aggregation and Provincial Price Relatives

Before calculating the price index, officially determined plasma FFB prices were aggregated into monthly averages for each province using the arithmetic mean of available daily price observations. The aggregation followed calendar months, including cases in which price-setting periods extended across two consecutive months. Each available daily observation was assigned equal weight, while missing price observations were not imputed. The monthly average price was calculated as follows (International Monetary Fund, 2004):

$$p_{it} = \frac{1}{n_{it}} \sum_{d \in D_{it}} p_{id}$$

where:

p_{it}: Average monthly officially determined plasma FFB price in province i during month t (Rp/kg)

p_{id}: Officially determined plasma FFB price applicable in province i on calendar day d (Rp/kg)
D_{it}: Set of calendar days in month t for which plasma FFB prices are available in province i
n_{it}: Number of days with available plasma FFB prices in province i during month t

The price index for each province was then calculated by comparing its monthly average price with the corresponding price in May 2025, as follows:

$$I_{it} = \frac{p_{it}}{p_{i0}} \times 100$$

where:
I_{it}: Price index for province i in month t
p_{it}: Average monthly officially determined plasma FFB price in province i during month t (Rp/kg)
p_{i0}: Average monthly officially determined plasma FFB price in province i during the base period, May 2025 (Rp/kg)

A price relative measures the change in price between a given period and a reference period (International Labour Organization et al., 2020). An index value of $I_{it} > 100$ indicates that the plasma FFB price in province i is higher than its level in May 2025, whereas $I_{it} < 100$ indicates a lower price relative to the base period. An index value of $I_{it} = 100$ indicates no change relative to the base period.

Calculation of Lowe Weights

The Lowe index allows the weight reference period (b) to differ from the price reference period (0) (International Labour Organization et al., 2020). In this study, annual CPO production from smallholder plantations in 2024 was used as a quantity proxy, while May 2025 was selected as the price reference period. Provincial weights were calculated by multiplying each province's plasma FFB price in the price reference period by its corresponding proxy quantity and dividing the result by the sum of these products across all 22 provinces, as follows:

$$w_i = \frac{p_{i0} \times q_{ib}}{\sum_{j=1}^{N} p_{j0} \times q_{jb}}$$

where:
w_i: Weight assigned to province i
p_{i0}: Average monthly officially determined plasma FFB price in province i during the base period, May 2025 (Rp/kg)
q_{ib}: Annual CPO production from smallholder plantations in province i in 2024 (tons), used as a proxy for the quantity of plasma FFB.
N: Total number of provinces included in the index ($N = 22$)

The sum of the weights across all 22 provinces equals one:

$$\sum_{i=1}^{N} w_i = 1$$

Calculation of the Aggregate Plasma FFB Price Index for 22 Provinces

The aggregate plasma FFB price index for 22 provinces was calculated using the Lowe index formula, which compares the values of a fixed quantity basket evaluated at current-period and price-reference-period prices (International Labour Organization et al., 2020). The same proxy quantities were applied to both periods, as expressed in the following equation:

$$I_t^A = \frac{\sum_{i=1}^{22} p_{it} \times q_{ib}}{\sum_{i=1}^{22} p_{i0} \times q_{ib}} \times 100$$

Equivalently, the aggregate index can be expressed as the weighted average of the provincial price indices:

$$I_t^A = \sum_{i=1}^{N} w_i \times I_{it}$$

where:
I_t^A: Aggregate plasma FFB price index for 22 provinces in month t
I_{it}: Plasma FFB price index for province i in month t
w_i: Weight assigned to province i
N: Total number of provinces included in the index ($N = 22$)

The Lowe index measures changes in the value of a fixed quantity basket when evaluated using prices from different periods (International Labour Organization et al., 2020). The index equals 100 in May 2025, the price reference period. The resulting index serves as an indicator for monitoring relative changes in officially determined plasma FFB prices across the 22 provinces studied. It does not measure actual transaction prices or imply uniform price changes across provinces.

Sensitivity Analysis of Alternative Weighting Scenarios

To evaluate the sensitivity of the aggregate price index to changes in the weight reference period, a deterministic sensitivity analysis was conducted using Mean Absolute Percentage Deviation (MAPD) (Białek & Beręsewicz, 2021; International Monetary Fund, 2004). The main specification, which used annual smallholder CPO production in 2024 as the quantity proxy, was compared with five alternative weighting scenarios:

1. Alternative Scenario 1: CPO production in 2022.
2. Alternative Scenario 2: CPO production in 2023.
3. Alternative Scenario 3: Average annual CPO production from 2022 to 2024.
4. Alternative Scenario 4: Average annual CPO production from 2023 to 2024.
5. Alternative Scenario 5: CPO production in May 2025 (Laspeyres-type specification).

All scenarios used the same price reference period (May 2025) and monthly plasma FFB price data, while the quantity proxies were derived from different production periods. Mean Absolute Percentage Deviation (MAPD) was used to measure deviations in the resulting index values, whereas Total Variation Distance (TVD) was used to measure differences in provincial weight distributions.

MAPD was calculated as follows:

$$MAPD_a = \frac{1}{m} \sum_{t=1}^{m} \left| \frac{I_{main,t} - I_{a,t}}{I_{main,t}} \right| \times 100\%$$

$MAPD_a$: Mean Absolute Percentage Deviation for alternative scenario a (%)
$I_{main,t}$: Lowe index under the main specification in month t
$I_{a,t}$: Index under alternative weighting scenario a in month t
m : Number of evaluation months (m = 16)

MAPD was calculated over 16 months, from June 2025 to September 2026, excluding May 2025. The price reference period was excluded because all index specifications equal 100 in that month, resulting in zero deviations between scenarios. The sensitivity analysis therefore focused on the subsequent months, during which differences in weighting structures could affect the index values.

The sensitivity analysis was conducted by comparing the magnitude of the relative deviation in index values between the main specification and each alternative weighting scenario (Białek & Beręsewicz, 2021; International Monetary Fund, 2004). A lower MAPD indicates a smaller average percentage deviation from the main specification. The results were compared across scenarios without applying a predetermined threshold for index stability. MAPD was therefore used to assess sensitivity to alternative weighting scenarios, rather than to determine the absolute accuracy of the index or conduct inferential statistical tests.

Differences in provincial weight distributions between the main specification and each alternative scenario were evaluated using Total Variation Distance (TVD). TVD measures the difference between two distributions as half the sum of the absolute differences between their corresponding components (Rabiu et al., 2023). In this study, TVD was used to assess the extent to which provincial weight distributions differed from those of the main specification based on 2024 CPO production, as follows:

$$TVD_a = \frac{1}{2}\sum_{i=1}^{22}\left|w_i^{(a)} - w_i^{(2024)}\right| \times 100\%$$

where:
TVD_a : Total Variation Distance for alternative scenario a (%)
$w_i^{(a)}$: Weight assigned to province i under alternative scenario a
$w_i^{(2024)}$: Weight assigned to province i under the main specification using 2024 CPO production

III. RESULTS AND DISCUSSION

Aggregate Plasma FFB Price Index Across 22 Provinces

The Lowe index calculation produced 17 monthly index values for May 2025–September 2026, covering 22 Indonesian provinces and yielding 374 province-month observations with no missing monthly price data. Consistency checks confirmed that the provincial weights summed to one, the index equaled 100 in the price reference period (May 2025), and the direct Lowe calculation produced results consistent with the weighted average of provincial price indices. Annual CPO production from smallholder plantations in 2024 was used as a quantity proxy to calculate the index weights. Riau (34.09%), South Sumatra (11.07%), and North Sumatra (10.85%) accounted for a combined weight of 56.00%, based on unrounded values. This concentration indicates that provinces with larger weights exert greater influence on the aggregate index for a given change in their provincial price indices.

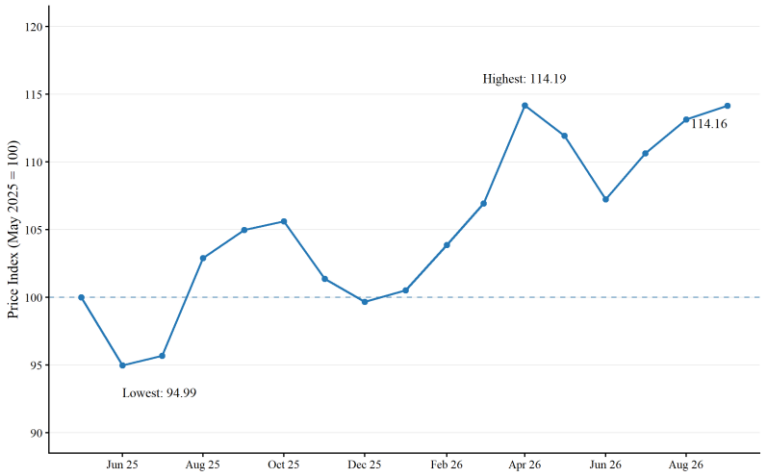


Figure 1. Changes in the Aggregate Plasma FFB Price Index Across 22 Provinces, May 2025–September 2026

As shown in Figure 1, the aggregate plasma FFB price index fluctuated throughout the observation period, with an overall upward trend. The index reached its lowest value of 94.99 in June 2025, representing a 5.01% decline relative to the price reference period. It subsequently increased to 105.63 in October 2025 before declining to 99.67 in December 2025. The index rose again in early 2026 and reached its highest value of 114.19 in April 2026, when it recorded the largest month-to-month increase of 7.24 index points compared with March 2026. Despite subsequent fluctuations, the index increased to 114.16 in September 2026, indicating a 14.16% increase in officially determined plasma FFB prices on an aggregate basis relative to May 2025. This increase does not directly represent changes in actual transaction prices or smallholder income.

The findings demonstrate that the Lowe index can summarize relative changes in officially determined plasma FFB prices across 22 provinces into a single indicator using a fixed weighting structure. The application of price indices to monitor commodity price movements has also been discussed by Melindah and Wulan (2024), although their study focused on food commodities. In the oil palm sector, Varwasih et al. (2023) examined the relationship between FFB prices received by independent smallholders and the CPO market, while Reich et al. (2026) discussed smallholders' vulnerability to FFB price fluctuations. These studies highlight the relevance of price monitoring but do not establish the causes of the index movements observed in the present study. The resulting index reflects aggregate changes in officially determined plasma FFB prices rather than changes in individual provincial prices or the effects of specific policies.

Sensitivity Analysis of Alternative Weighting Scenarios

The deterministic sensitivity analysis showed that alternative weight reference periods resulted in relatively small deviations from the main specification, which used 2024 smallholder CPO production as the quantity proxy. As presented in Table 2, the Mean Absolute Percentage Deviation (MAPD) ranged from 0.0039% to 0.0846% across the five alternative weighting scenarios. The lowest MAPD was observed under the average 2023–2024 production scenario (0.0039%), whereas the highest occurred under the May 2025 production scenario (Laspeyres-type specification), at 0.0846%. Meanwhile, the largest maximum absolute difference of 0.2142 index points was observed under the 2022 production scenario. These results indicate that the alternative weighting periods examined produced only minor differences in the aggregate index values.

Table 2. Sensitivity Analysis of the Lowe Index Under Five Alternative Weighting Scenarios

Weighting Scenario	TVD (%)	MAPD (%)	Maximum absolute difference (index points)
2023–2024 Average	0.46	0.0039	0.0124
Year 2023	0.95	0.0081	0.0254
Average 2022–2024	1.74	0.0210	0.0753
Year 2022	4.69	0.0591	0.2142
May 2025 (Laspeyres-type)	4.99	0.0846	0.1783

Note: The main specification used 2024 smallholder CPO production as the quantity proxy. MAPD was calculated over 16 months (June 2025–September 2026), excluding the price reference period.

Total Variation Distance (TVD) values ranged from 0.46% to 4.99%, indicating differences in provincial weight distributions relative to the main specification. The average 2023–2024 production scenario yielded the lowest TVD (0.46%), while the May 2025 production scenario yielded the highest (4.99%). The ranking of TVD values across the five scenarios corresponded to that of MAPD values, with scenarios exhibiting greater differences in weight distributions also showing larger average deviations in index values. Nevertheless, all MAPD values remained below 0.1%, including the scenario with a TVD of 4.99%. These findings suggest that changes in provincial weight distributions across the scenarios examined were accompanied by relatively small deviations in the resulting aggregate index. However, this descriptive relationship does not establish that differences in weight distributions directly determine index deviations, nor do the low MAPD values demonstrate that the 2024 weights are the most accurate or representative.

Using a full-year weight reference period was intended to reduce reliance on production conditions in a single month, which may be influenced by seasonal factors (International Monetary Fund, 2004). Although the sensitivity analysis indicated relatively small differences in index values across the tested scenarios, these findings do not establish that the 2024 weights are the most accurate or that seasonal influences have been eliminated. Furthermore, smallholder CPO production was used as a proxy for plasma FFB quantities, which may not fully represent the production structure of the population covered by the price data. Monthly average prices were also calculated from available daily observations without imputing missing values. Consequently, monthly averages based on incomplete daily coverage may not fully represent prices throughout the corresponding calendar month.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

This study compiled an aggregate plasma FFB price index across 22 Indonesian provinces using the Lowe index to monitor relative changes in officially determined plasma FFB prices over time. With May 2025 as the price reference period (index = 100) and 2024 CPO production from smallholder plantations as a quantity proxy, the index fluctuated throughout the observation period and stood at 114.16 in September 2026, representing a 14.16% increase relative to May 2025. The sensitivity analysis across five alternative weighting scenarios yielded Mean Absolute Percentage Deviation (MAPD) values ranging from 0.0039% to 0.0846% and Total Variation Distance (TVD) values ranging from 0.46% to 4.99%. These findings indicate that differences in provincial weight distributions across the tested scenarios were accompanied by relatively small deviations in the resulting index values. Therefore, the index can serve as an indicator for monitoring relative changes in officially determined plasma FFB prices across the 22 provinces studied, subject to the limitations of using proxy quantities and the scope of the sensitivity analysis.

Recommendations

Future research should evaluate the suitability of CPO production from smallholder plantations as a proxy for plasma FFB quantities, given the limited availability of provincial plasma FFB production data. If such data become available, their use as quantity weights could be considered to improve the alignment between the price data coverage and the production quantities used for weighting. In addition, future studies should extend the observation period and periodically review the weighting structure to assess the sensitivity of the index to changes in production distributions across provinces.

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