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Production and Income of Clove Farming in Latuo Village, Southeast Sulawesi: A Comparative Analysis between 2023 and 2024

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A B S T R A C T

This study analyzes the production and income of clove farming in Latuo Village in Kolaka Regency, Southeast Sulawesi, by comparing the 2023 and 2024 farming seasons. All 20 clove-farming households in the village were surveyed. Using farm income analysis and a paired t-test, we examine whether there were significant differences in clove production and farmers' net income between the two years. The results show that average clove yield per farmer increased from about 84 kg in 2023 to 453 kg in 2024, and this difference was statistically significant. Likewise, average net income per farmer rose dramatically from approximately IDR 4.7 million in 2023 to IDR 42.5 million in 2024, also a statistically significant change. The surge in income outpaced the rise in production, indicating that factors beyond sheer output, notably fluctuations in clove prices, played a substantial role. The findings suggest that 2023's low income was primarily due to a poor harvest compounded by relatively low farm-gate prices, whereas 2024 benefited from a rebound in yield and more favorable market prices. Climate variability appears to be a key driver of the yield differences. The findings highlight the need for policies to help clove farmers manage climate and price risks, for example, through improved farm management training, diversification of income sources, introduction of crop insurance or price stabilization mechanisms, and support for climate change adaptation strategies.

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INTRODUCTION

Clove (Syzygium aromaticum) is a high-value spice crop of great economic significance in Indonesia. The country accounts for over two-thirds of global clove production (Agence France-Presse AFP, 2025; Moore & Saragih, 2025), with much of the harvest used domestically (particularly in the kretek clove cigarette industry). Within Indonesia, Southeast Sulawesi (including Kolaka Regency) is among the major clove-producing regions (Hasim et al., 2025; Lestari et al., 2023; Saediman, 2015) (Hasim et al., 2025; Lestari et al., 2023). Clove cultivation is predominantly carried out by smallholder farmers in rural areas, making it an important source of livelihood and rural income (Lestari et al., 2023; Surni & Saediman, 2020; Utama et al., 2018). When clove harvests are abundant and prices are favorable, farming households can earn substantial profits, contributing to local economic welfare (Kumala et al., 2025). However, the clove industry faces notable challenges, chiefly stemming from climate variability and market price fluctuations.

In recent years, climate change has emerged as a serious threat to clove production (Agence France-Presse AFP, 2025; Moore & Saragih, 2025). Clove trees are highly sensitive to weather conditions as they require specific patterns of rainfall and temperature for flowering and fruiting (Ali et al., 2025). Extreme or unseasonal weather can drastically reduce yields. Indeed, farmers in Indonesia's traditional clove-growing areas report that erratic rainfall and rising temperatures have upset the once-reliable production cycles (Agence France-Presse AFP, 2025). Scientific studies confirm these observations. For example, an analysis in North Maluku found that rainfall had increased 15% in recent decades, contributing to more frequent crop failures and yield declines in clove orchards. As a result, annual clove yields now vary significantly, with some years seeing much lower output than others (Agence France-Presse AFP, 2025; Moore & Saragih, 2025). Farmers note that "cloves do not bear fruit every year; they depend on the season" (Agence France-Presse AFP, 2025), a reflection of the clove tree's tendency toward alternate (irregular) bearing, where a good harvest year may be followed by a poor year. This inherent biological cycle, exacerbated by unfavorable weather in certain years (Saediman et al., 2020), leads to pronounced swings in production at the farm level.

The market side of clove farming adds another layer of uncertainty. Indonesian clove prices have historically been volatile, influenced by both domestic demand (e.g. from the cigarette industry) and global spice market conditions. Over the past two decades, clove production and prices have fluctuated with an overall modest upward trend, but year-to-year changes can be sharp (Nurdiana, 2023). Crucially, when output is high, prices often fall, and when output is low, prices tend to rise. However, farmers may not always benefit from price spikes if their own harvest is poor, nor are they protected from price drops when they happen to have a bounty. For instance, an AFP report noted that in 2024, as clove supply increased during the harvest season, farm-gate prices in Indonesia plummeted from around IDR 150,000 per kilogram to IDR 80,000, before rebounding to roughly IDR 115,000 as supply tightened later (Agence France-Presse AFP, 2025). Such intra-year price swings of nearly 50% make it difficult for farmers to predict income. Moreover, clove

farmers often lack alternative income sources, so a bad year of low yield and low price can be devastating for their earnings (Agence France-Presse AFP, 2025; Ali et al., 2025). Studies in other clove-producing communities have shown that these "ups and downs" in clove output and price directly affect household welfare; when clove income drops, families struggle to meet basic needs (Kumala et al., 2025; Pratama & Darwanto, 2019).

Latuo Village, in Samaturu District of Kolaka, Southeast Sulawesi, provides a salient case study of these issues. This village is known for clove farming, and like many rural communities, its economy is closely tied to the annual clove harvest. Farmers in the village have reported that climate factors (especially rainfall patterns) and fluctuating clove prices have made their farming income very uncertain in recent years. In particular, there were anecdotes of a disappointing clove season in 2023, characterized by low production, followed by a much more productive season in 2024. Such a sudden change presents an opportunity to quantitatively assess how much farmers' fortunes can shift from one year to the next, and to investigate what might be driving those changes. Understanding these dynamics is crucial for devising strategies to improve income stability and resilience for clove farmers.

LITERATURE REVIEW

This research was undertaken to analyze the production and income of clove farming in Latuo Village for the years 2023 and 2024, and to determine whether the differences observed between these two years are statistically significant. We focus on two main indicators: the physical production of cloves (yield per farmer) and the net farming income (profit) earned by farmers from clove cultivation. By using a paired t-test to compare 2024 against 2023, we test the hypothesis that there were no significant changes in production and income. Given the context, we expected that 2024 might show higher production and income, potentially significantly so, owing to more favorable conditions. We also aim to analyze the factors contributing to any observed changes, particularly the roles of weather/climate and price fluctuations.

METHODOLOGY

Research Site and Respondents

This study was conducted in Latuo Village, which is located in Samaturu District of Kolaka Regency, Southeast Sulawesi, Indonesia. Latuo has a tropical climate with a distinct wet season and dry season (typical of Sulawesi's monsoonal pattern). According to local climate data, the Kolaka area receives roughly 2,700 mm of rain annually, but rainfall is unevenly distributed: the months of December through April tend to be very wet, whereas a drier spell occurs around August–September. Such climate conditions are suitable for clove cultivation, although the timing and intensity of rainfall can greatly influence clove flowering and harvest success (Ali et al., 2025). Latuo's terrain and soil are conducive to perennial tree crops. Besides cloves, farmers in the region also grow crops like cocoa, coconut, pepper, coffee, cashew, nutmeg, and patchouli (Badan Pusat Statistik Kabupaten Kolaka, 2023; Geo & Saediman,

2019; Saediman, Kurniansi, et al., 2019), but cloves are a principal cash crop in this village. The study population consisted of all clove farmers in Latuo Village. Given that the village has a relatively small number of clove-farming households, we adopted a census sampling approach in which every household engaged in clove farming was included as a respondent. In total, 20 clove farmers were identified and participated in the study. The farmers in our study varied in demographic and farm characteristics, but all shared the experience of cultivating clove trees and harvesting cloves as part of their livelihood.

Data Collection

We collected primary data through interviews and farm surveys conducted in late 2024 and early 2025. A structured questionnaire was used to gather detailed information from each farmer about their clove farming activities in the years 2023 and 2024. Key data points included clove production, clove prices and revenue, and production costs.

Clove production (yield) in each year was measured in kilograms of dried clove buds produced by the farmer. Farmers typically harvest cloves once per year (around the middle of the year, depending on when the buds are ready, often August–September). We asked farmers to recall or consult their records for the total harvest in 2023 and in 2024. In some cases, if the farmer had multiple small harvests within the year, these were summed to get an annual total. With respect to clove prices and revenue, we asked what average price the farmer obtained for their cloves and how they sold their product. Using yield and price data, we computed the total revenue from clove sales for 2023 and 2024 for each farmer. Revenue is simply yield multiplied by price. We recognized that prices can fluctuate even within the harvest season, so we either took an average price if the farmer sold in batches, or the price at the major sale of their crop.

We also gathered data on the costs incurred in clove farming for each year. This included both variable costs (such as expenditures on labor for harvest, pesticides, or fertilizers if used, transport, etc.) and any fixed costs (such as equipment depreciation). Most clove farmers in the village have relatively low input systems; many do not use chemical fertilizers or intensive inputs, relying mainly on family labor and perhaps some hired labor during harvest. Nonetheless, to calculate net income (profit), it was important to account for costs. Farmers provided estimates of any cash expenses and the imputed cost of family labor or other resources.

Data Analysis

Data analysis uses cost and returns analysis and a paired t-test. From the revenue and cost data, we calculated net farm income from clove farming for each respondent in each year. Net income (often simply called "income" in this paper for brevity) is defined as total revenue minus total costs (Lumampa et al., 2019; Saediman, Mustika, et al., 2019). In formula form:

$$\textbf{Net Income} = \textbf{Total Revenue} - \textbf{Total Production Costs}$$

Total revenue refers to the gross income that a farmer earns from selling clove produce. This value is determined by multiplying the quantity of clove produced during the farming season by the prevailing market price per unit. Total production cost encompasses all expenses incurred throughout the

farming cycle. These costs are typically categorized into two components: fixed costs and variable costs. By subtracting the total cost (comprising both fixed and variable components) from the total revenue, the resulting figure represents the net income earned from clove farming. This metric serves as a key indicator of the economic viability and profitability of the farming enterprise.

This net income represents the return to the farmer's labor, management, land, and capital after paying all expenses. It is the key measure of economic benefit that the farmer gains from clove farming. In addition to quantitative data, the interviews collected qualitative information. We asked farmers open-ended questions about any factors they believed affected their 2023 vs 2024 production and income. These qualitative responses helped interpret our findings, though our analysis of differences relies on the quantitative data.

To formally test whether the differences between 2023 and 2024 were statistically significant, we employed a paired samples t-test. This test is appropriate because we have two sets of observations (2023 and 2024) on the same subjects (the same 20 farmers). The null hypothesis was that the mean difference in production between 2024 and 2023 is zero (no change), and similarly that the mean difference in income is zero. The alternative hypothesis is that the mean difference is not zero (there is a change). We conducted two separate t-tests: one for the production data and one for the income data. For each t-test, we computed the difference (2024 minus 2023) for each farmer, then calculated the mean of these differences and their standard deviation. The t-test uses these to calculate a t-statistic:

$$t_{calc} = \frac{\bar{d}}{s_d / \sqrt{n}}$$

Where d is the differences between each pair of data, Sd is the standard deviation of the differences, and n is the number of paired observations. We then compared the t-statistic against the critical value from the t-distribution with n-1 degrees of freedom for a chosen significance level alpha = 0.05 (95% confidence level). The test yields a p-value indicating the probability of observing the given mean difference (or more extreme) if the true mean difference were zero. We considered a result statistically significant if $p < 0.05$. Additionally, we checked the 95% confidence interval for the mean difference, which provides a range of values that likely contains the true mean difference.

RESULT AND DISCUSSION

Clove Production in 2023 and 2024

The data reveal a striking increase in clove production from 2023 to 2024 among Latuo Village farmers. The total clove production of Latuo Village was around 1.64 tons in 2023, whereas in 2024 it was about 9.05 tons. This means a more than fivefold increase in aggregate output. In 2023, clove yields were exceptionally low for nearly all farmers. The average production per farmer in 2023 was only about 82–84 kg of dried clove buds for the year. Several farmers harvested well under 50 kg, and a few had virtually no harvest due to poor

flowering of the trees that year. In contrast, in 2024 the clove output surged: the average production per farmer jumped to approximately 452–453 kg. Every single farmer saw a higher yield in 2024 than in 2023, though the magnitude of improvement varied. Some got a few hundred extra kilograms, others, whose trees are more mature, got up to 500-600 kg more.

Such a year-over-year jump is unusual for most crops, but not unheard of for cloves given their irregular bearing pattern. Clove trees often have "on" years and "off" years. Field observations and farmers' experiences suggest that 2023 was effectively an "off" year, as many clove trees did not flower or fruit much in that season. In contrast, 2024 was an "on" year with abundant flowering and fruit set. The reasons for this pattern can be multi-fold. A major factor cited by farmers and supported by our qualitative findings is weather conditions. In interviews, farmers mentioned that 2023 had excessive rainfall during critical periods (for example, rain during what should have been a dry spell needed for flower induction) or other unfavourable climate events, leading to a poor clove crop. Conversely, 2024's weather was described as more balanced, with a sufficiently pronounced dry season allowing the trees to flower, followed by well-timed rains that did not disrupt the harvest. This aligns with broader climate-agriculture linkages that clove yields have been shown to correlate strongly with rainfall patterns. One study in Zanzibar found a positive correlation between annual rainfall and clove production (Ali et al., 2025), and a negative correlation with temperature spikes. Excess or untimely rain can hamper flowering and increase disease, whereas moderate, well-timed rain supports good yields (Ali et al., 2025).

Additionally, the biology of clove trees means that after a heavy fruiting year, trees may need a restorative period before the next heavy bloom. The phenomenon of alternate bearing in cloves (observed in Indonesia and other clove-producing countries) is well documented in agronomic literature (Thankamani et al., 1994). Essentially, a clove tree that produces abundantly in one year might produce very little the next year, as it reallocates energy to vegetative growth or simply because of the plant's internal cycles. In our case, it is possible that 2022 (the year before our study period) had a decent harvest in Latuo, which could partially explain the very poor 2023 yield, i.e., an alternate bearing effect. However, farmers did not uniformly recall 2022 outcomes, and climate was the more consistently cited factor for 2023's bad harvest. 2023's low yield was likely a combination of natural bearing cycle and adverse weather, both of which led to minimal flowering. By 2024, the trees were both ready for an "on" cycle and benefited from friendlier weather, resulting in the explosion of production.

The paired t-test analysis for production confirms that the difference between 2023 and 2024 production is statistically significant (Table 1). The average increase in yield per farmer was about 368.5. The t-test yielded a t statistic of approximately 6.15 with 19 degrees of freedom, and a p-value < 0.001. This leads us to reject the null hypothesis of no difference and conclude that 2024's production was significantly higher than 2023's. These statistics

quantitatively back up what is visually obvious from the raw data, that the change is not just a random fluctuation but a real jump.

Table 1. Paired t-Test Results for Differences in Clove Production (2023 vs 2024)

Variable	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Production 2023	84.00	145.47	32.53					
Production 2024	452.50	252.08	56.37					
Difference (2023 - 2024)	-368.50	268.12	59.95	-493.98	-243.02	-6.15	19	.000

From a theoretical standpoint, this result is a vivid example of how climate-induced yield variability can manifest in tree crops. It resonates with reports from other clove regions. For example, farmers in Ternate (North Maluku) have described how a once-reliable clove tree now only gives "two to three sacks" of cloves in a bad year versus "five to six sacks" in a good year (Agence France-Presse AFP, 2025). That is a similar scale of fluctuation (roughly 50% or more drop in poor years) as we observed in Latuo. The Food and Agriculture Organization (FAO) data also indicate Indonesia's clove yields have swung widely year to year, with national output in 2023 about 25% below a prior peak (Agence France-Presse AFP, 2025; Moore & Saragih, 2025). Our micro-level findings thus mirror these macro trends, attributing them to localized weather impacts and the alternating fruiting tendency of clove trees.

It is important to note that not all farmers experienced identical increases. Some smaller producers might have gone from, say, 50 kg to 200 kg (4x increase), whereas a larger producer might go from 150 kg to 800 kg (over 5x increase). But the direction of change was unanimous: everyone produced more in 2024. There were also differences in absolute yield levels due to farm size and tree age. For instance, farmers with more mature trees harvested more overall. However, because we used a paired test, these between-farm differences are controlled for.

Clove Farming Income in 2023 and 2024

The net income that farmers derived from clove farming skyrocketed in 2024 as compared to 2023. On average, a clove farmer in Latuo earned only around IDR 4-5 million (approximately USD 300) as net income from the 2023 clove season. This figure is exceedingly low and is barely a subsistence level of return, considering it represents a year's earnings from the main cash crop. Indeed, some farmers indicated that in 2023, they made almost no profit. By contrast, in 2024, the average net income from clove farming shot up to about IDR 42.5 million (around USD 2,800). This is a life-changing amount for these small farmers, representing roughly nine times the previous year's income. Many farmers said 2024 was one of the best clove seasons in memory in terms of earnings.

Breaking down the numbers, the mean net income for 2023 was IDR 4,692,483, while for 2024 it was IDR 42,544,983. The difference in means is IDR 37,852,500. We subjected the income data to a paired t-test, just as with production. As shown in Table 2, the t-test for income difference also showed a statistically significant change, with $p < 0.001$. In fact, given the magnitude of the income jump and the relatively low variation among farmers, the statistical significance is very strong. The implication is that there is essentially no overlap between the distribution of incomes in 2023 and that in 2024.

Table 2. Paired t-Test Results for Differences in Clove Farming Income (2023 vs 2024)

Variable	Mean	Std. Deviation	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	Sig. (2-tailed)
Income 2023	4,682,083	17,218,945.07	3,850,273.17					
Income 2024	42,534,583	26,477,796.37	5,920,615.26					
Difference (2023 - 2024)	-47,216,666	34,197,685.28	7,646,834.90	-63,221,675.38	-31,211,656.62	-6.18	19	.000

The more interesting discussion is why income increased even more proportionally than production did. Production in 2024 was about 5.5 times higher than in 2023 on average, yet income was about 9 times higher. This discrepancy means that farmers did not just harvest more cloves, but they likely also benefited from better prices and/or lower costs per unit in 2024. We analyze two main components: price effects and cost effects.

- Price Effects: Using the revenue data, we can infer the average price per kilogram that farmers received each year. For 2023, if an average farmer produced 84 kg and earned IDR 4.7 million gross, the implied price is roughly IDR 56,000 per kg. For 2024, with 453 kg yielding IDR 42.5 million gross, the implied price is about IDR 94,000 per kg. These calculations suggest that the price of cloves was substantially higher in 2024 than in 2023 for Latuo farmers, and the increase was about 60-70%. This aligns with reports that clove prices rebounded in late 2024 due to tightening supply (Agence France-Presse AFP, 2025). It might seem counterintuitive that price was higher in a year when our village had a bumper crop, but remember that clove is a wider market: if 2024 happened to be a down year in some other regions or overall production nationally dropped (perhaps due to climate issues elsewhere), the price could rise. Indeed, news sources in 2025 noted that national clove production was down 30-40% compared to recent years (Agence France-Presse AFP, 2025), which could have caused prices to increase. Another possibility is timing: some Latuo farmers may have stored part of their 2024 harvest and sold later when the price improved towards the end of the year. In contrast, 2023's cloves might have been sold at harvest time when prices were at a low point. The net result is that farmers got a

double benefit in 2024: much higher volume and a better price per unit, multiplying the income impact. This demonstrates the volatility and importance of market prices: as one report emphasized, clove price issues remain a major challenge for farmers, with fluctuations that can make or break a season (Nurdiana, 2023).

- Cost Effects: Costs did increase in 2024, but not nearly to the same extent as output. For example, with more clove buds to pick and process, farmers had to hire extra labor or spend more time harvesting in 2024. Some farmers might have invested a bit more in farm inputs (such as buying more tarps for drying, or more sacks for packing). However, these costs are relatively small compared to the value of the crop. Clove farming is not input-intensive in terms of fertilizers or seeds each year (clove trees are perennial). The major cost is labor for picking, which, while significant, would only marginally reduce the huge revenue gain. We estimate that the average total cost per farmer might have been a few million rupiah in 2024 (depending on how much hired labor was used), versus perhaps under a million in 2023. So, even if costs maybe doubled or tripled, that's inconsequential when revenue increased almost tenfold. In essence, economies of scale kicked in: fixed costs (like maintaining the farm) were spread over a larger output in 2024, so the cost per kg was lower, boosting profit margin. Farmers thus experienced not just higher income, but likely a higher profit rate (percentage of revenue that is profit) in 2024.

The significance of this income jump for the farmers' livelihoods cannot be overstated. In 2023, many households barely earned enough from cloves to supplement their subsistence. They likely relied on other side jobs or crops (if available) to get by. Many clove farmers in such situations are pushed below the poverty line in bad years and have to cut back on expenditures (Kumala et al., 2025). In 2024, however, the clove income for some families would have been sufficient to, for example, make household investments (like home repairs or school fees for children) and pay off debts. A recent study in Bulukumba District, another clove-producing area in South Sulawesi, demonstrated that increased clove yields significantly improved family welfare, moving many households into higher well-being categories when clove income was strong (Kumala et al., 2025). Our findings echo this: one could reasonably expect that the welfare of Latuo's farming families improved in 2024 due to the windfall. Conversely, the 2023 plight underscores the vulnerability: farmers' welfare dropped when clove income plunged, illustrating how closely tied their fortunes are to this single commodity.

From a policy and development perspective, these dramatic income fluctuations raise concerns about income stability and rural poverty cycles. Clove farmers, like many smallholders of perennial crops, face what can be termed income vulnerability. They are exposed to risks of both yield shocks (from weather, pests, etc.) and price shocks (from market volatility) (Celio et al., 2023). A study in Madagascar found that smallholder spice farmers' incomes are highly vulnerable to such risks, especially in the absence of diversification

or safety nets (Celio et al., 2023). In our case, Latuo farmers endured a very tough year, followed by an excellent year. While the good year may compensate on average, the interim hardships and uncertainty can have lasting effects (for instance, some farmers might take loans in bad years and then have to use good-year earnings to pay debt rather than invest or save). The challenge for rural development is to find ways to smooth these income fluctuations or help farmers cope with them.

Factors Influencing Changes

As mentioned previously, the two dominant factors that explain the 2023–2024 differences are climate (production side) and price (market side). The following is a more detailed description of the two factors, partly integrating insights from the broader literature to validate the causal linkages:

1. Climate Factors

Latuo Village farmers unanimously pointed to rainfall differences as a key determinant of their clove yields. In tropical tree crops like cloves, rainfall timing is crucial. A well-timed dry period can induce flowering, and subsequent moderate rains support fruit development, but continuous rain or erratic swings can damage flowers and buds (Agence France-Presse AFP, 2025; Ali et al., 2025). According to local accounts, 2023 had unseasonal rain during what should have been the flowering induction phase (around June-July of 2023, perhaps), leading to poor flowering. Thereafter, some heavy rains possibly knocked off the few flowers that emerged. In contrast, 2024 had a more defined dry spell, and rains came at the "right" times, allowing abundant flowering and a successful fruit set. These observations are consistent with climate data trends; Kolaka BPS (Central Statistics Agency) records show variability in monthly rainfall year to year (Badan Pusat Statistik Kabupaten Kolaka, 2017, 2024). Climate change could be contributing to these anomalies. Farmers in Ternate have described the current climate as "often unpredictable" with rainfall patterns no longer following historical norms (Agence France-Presse AFP, 2025). When rain comes in "intense, damaging bursts" after unusual dry spells (Moore & Saragih, 2025), it can severely impact crops like clove that depend on gradual seasonal rhythms. Researchers have indeed found that higher rainfall variability and extremes in parts of Maluku and Sulawesi correlate with drops in clove yields (Agence France-Presse AFP, 2025; Moore & Saragih, 2025). Our study reinforces this: rainfall variability between 2023 and 2024 was a decisive factor in yield outcome (with 2024 benefiting from a more favorable pattern). This suggests that as climate change progresses, without adaptation, clove farmers could face increasingly frequent bad years. Already, some farmers report needing two years to recover from one failed clove season (Agence France-Presse AFP, 2025), which indicates a precarious situation if climate extremes become more common.

2. Price and Market Factors

While climate governed how many cloves farmers could harvest, the market determined how much those cloves were worth. The nearly 10-fold income difference was partly because 2024's cloves fetched a higher price per kg than 2023's. Even though local supply in Latuo was abundant in 2024 (which

alone might have pressured prices downward if considered in isolation), clove prices are set on a larger regional/national market. We suspect that overall, Indonesia's clove output did not flood the market in 2024. As mentioned, some estimates suggest a production decline nationally, which would tighten supply and raise prices (Agence France-Presse AFP, 2025). Thus, 2024 turned out to be a sweet spot for Latuo farmers: they had a bumper crop in a year when cloves were relatively expensive. On the other hand, 2023's low village yield unfortunately did not coincide with extremely high prices, perhaps because other areas had moderate production or because buyers still forced prices down. One source noted that in 2023, Indonesia's clove harvest was below peak, yet not scarce enough to cause a price spike to record levels (Agence France-Presse AFP, 2025) (price might have been around IDR 60k-70k/kg that year, which is decent but not spectacular). Thus, 2023 was a disappointment both in volume and price terms for Latuo farmers.

Price fluctuations in cloves are influenced by domestic demand cycles (kretek factories have buying seasons) and international trade. Indonesia used to be a net clove importer when local demand exceeded production in some years (especially in the 1990s), but more recently, with variable production, Indonesia has sometimes exported cloves when there is a surplus. Global clove prices also experience volatility. For instance, Madagascar (a big exporter) had some poor harvests in recent years, driving global prices up. The complexity of these factors is beyond the scope of our local study, but the key takeaway is that price volatility amplified the income volatility. It is exactly as one clove supplier described: if the weather is too hot or too wet, you get no crop; if you get no crop, supply falls and later prices rise, but the farmer who had no crop cannot benefit from that (Agence France-Presse AFP, 2025). Conversely, if you have a huge crop and everyone does too, prices fall and undercut your potential earnings. The best scenario for a farmer is to have a good crop when not everyone else does. In 2024, Latuo farmers may have hit that scenario to some extent, which is partly luck.

There were no indications of other major factors (such as changes in farming practices or policies) that differed between the two years in our study. All farmers largely followed their usual cultivation practices in both years. There was no introduction of new high-yielding clove varieties or special fertilizers between 2023 and 2024. Thus, we can confidently attribute the differences to the external factors above. One could argue that farm management (pruning, weeding, etc.) might affect yield year to year, but farmers generally maintain their clove gardens consistently. If anything, some farmers were discouraged by the bad 2023 and might have invested less in maintenance that year (because they saw little fruit), but that is more a reaction than a root cause.

Theory and Policy Implications

The findings from Latuo Village reinforce several theoretical insights in agricultural economics and rural development. They provide a concrete example of income instability in smallholder agriculture. It has often been suggested that farmers who specialize in a single cash crop are highly exposed

to yield and price risks (Reading & Soussan, 1989; Serfilippi et al., 2020). Our data exemplify this, as clove-specialized farmers saw nearly an order-of-magnitude swing in income in one year. According to vulnerability frameworks (Celio et al., 2023), these farmers have high exposure (to climate and market shocks), high sensitivity (because clove income is a large share of total income), and limited adaptive capacity (few alternative livelihoods), making them vulnerable to welfare losses in bad years.

The results align with climate-agriculture models, which predict that greater climate variability will lead to greater yield variability and hence income volatility, especially for perennial crops that are sensitive to weather patterns (Agence France-Presse AFP, 2025). Our case contributes empirical evidence of how a climate anomaly (in this case, likely a rainfall anomaly) translates into economic outcomes. This can inform climate impact assessments and the need for adaptation strategies for tree crops.

From a development policy perspective, it highlights the concept of "boom and bust" cycles in rural communities dependent on commodities (Castella et al., 2023; Pretes & Robinson, 1989). Without interventions, a boom year's gains might not fully compensate for a bust year's losses in terms of long-term development (families might use the boom income to pay debts incurred in the bust, etc.). This resonates with theories on commodity price stabilization and the role of institutions: some economists argue that government or cooperatives should help stabilize producer prices or help farmers save windfall gains to use in lean times.

The situation also underscores the importance of diversification as a theoretical and practical risk mitigation strategy (Mgale & Yunxian, 2021; Shimelis & Bogale, 2007). Classic portfolio theory applied to farm livelihoods suggests that diversifying income sources (e.g., growing other crops or engaging in non-farm work) can reduce overall income variance (Saediman et al., 2021). Indeed, we heard that some Latuo farmers have secondary incomes, and those who did were somewhat more cushioned in 2023. However, diversification is not always easy or desirable if clove is far more profitable in a good year. Many farmers stick to cloves due to their high potential payoff, which is rational but risky (akin to a high-risk, high-reward investment). Studies in Madagascar's spice regions noted that households try to maintain some subsistence crop (like rice) to hedge against cash crop failures (Celio et al., 2023).

Considering other literature in Indonesia, it's worth noting that clove has historically been a boom-and-bust crop nationally as well. There was the great "clove crisis" in the 1980s/90s with government monopsonies and price crashes, etc. While those policy-driven crises are not the case here, the inherent instability remains. A 2024 study in North Kolaka identified that price unpredictability is a primary concern for clove farmers, affecting their motivation and sustainability in clove cultivation (Nurdiana, 2023).

This case study reinforces concepts in the literature regarding the vulnerability of smallholder cash-crop farmers. It provides empirical support for the idea that income volatility in agriculture (especially in perennial tree

crops) is a function of both biophysical yield risk and market risk. The magnitude of change observed here contributes to an understanding of risk exposure among spice farmers, complementing studies on climate change impacts and price transmission in agricultural markets. Additionally, the findings highlight the importance of timing and the covariance of risks. In some years, multiple favorable factors can coincide (yield and price booms together, as in 2024, leading to windfall gains), whereas in other years, the negative factors coincide (yield failure and lack of price compensation, as in 2023). Our study also underscores the relevance of traditional knowledge (farmers' observations of climate and crop patterns) (Amirat et al., 2021) in explaining statistical outcomes, bridging quantitative analysis with grounded insights, an approach increasingly advocated in sustainable agriculture research.

Given the above, there are clear policy implications and practical recommendations to help clove farmers like those in Latuo Village. They include climate adaptation measures, price stabilization and market support, income diversification and livelihood resilience, financial tools (savings and insurance), and research and extension.

CONCLUSIONS AND RECOMMENDATIONS

This study set out to analyze the production and income of clove farming in Latuo Village for the years 2023 and 2024, and to investigate the reasons behind any significant changes. The results showed that 2024 far outperformed 2023 in both clove output and farmers' income, and these differences were statistically significant and economically substantial. On average, a Latuo farmer's clove production increased by over five times and net income by about nine times from 2023 to 2024, with the paired t-tests confirming the robustness of these changes.

The evidence points to climatic factors as the primary driver of the production increase. The year 2024 provided a more favorable growing season (likely due to better rainfall timing), whereas 2023's clove harvest was depressed by adverse weather and the natural alternate bearing cycle of clove trees. In turn, the dramatic income gain was driven not only by the higher yield but also by improved clove prices in 2024, illustrating how market conditions can amplify or mitigate the impact of agricultural output changes. In 2024, Latuo farmers had the good fortune of "high yield–high price", whereas 2023 was a "low yield–moderate price" scenario that proved challenging for livelihoods.

For policymakers and stakeholders in Indonesia's agricultural sector, the findings serve as a microcosm of the challenges faced by clove farmers and similar commodity producers. Some measures that can be done include investing in climate adaptation, establishing financial instruments to buffer farmers in bad years, providing market interventions or support, providing rural credit and savings programs, and public-private partnerships.

FURTHER STUDY

Future research could build on this study by examining longer time series, by exploring similar analyses in other villages or regions for comparison, and by delving into specific adaptation strategies employed by farmers. One area worth exploring is the social dimension, namely how households coped in the low-income year, and how they invested or spent in the high-income year.

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