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From Leaf to Extract: A Cost-Benefit and Input-Output Assessment of Kratom Down streaming in Indonesia

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Abstract

Indonesia is one of the world's largest producers of kratom (Mitragyna speciosa), yet it captures only a small share of the value generated along the global kratom value chain. The enactment of Permendag 20/2024 and 21/2024 in October 2024, which prohibits raw kratom leaf exports and mandates processed-form exports, has created both an obligation and an opportunity to move downstream into high-purity extraction. This study assesses the financial feasibility and macroeconomic impact of producing fifty-percent *mitragynine* extract at a commercial scale of one hundred kilograms per month, using the case of PT MIT as the unit of analysis. An integrated framework combining a firm-level Cost-Benefit Analysis with an Input-Output Analysis is applied, grounded in validated pilot operational data and the 2020 Indonesian Input-Output Table. Three scenarios distinguished by capacity utilization of seventy-five, eighty-five, and ninety-three percent are evaluated at a fifteen-percent discount rate. The financial results indicate strong viability: the base case yields a net present value of Rp 11.80 billion, an internal rate of return of 37.59 percent, a profitability index of 2.31, and a discounted payback of 4.88 years. The macroeconomic results show that the pharmaceutical sector to which kratom extraction is mapped functions as a strong demand-pull sector, generating total economy-wide output of Rp 48.37 billion, supporting around ninety-three jobs, and contributing foreign exchange of USD 1.53 million per year. The study demonstrates that domestic down streaming aligns private profitability with national economic benefit.

INTRODUCTION

Indonesia is a leading global producer of kratom (Mitragyna speciosa), a botanical commodity cultivated primarily in West Kalimantan whose alkaloid *mitragynine* has gained substantial international market demand in pharmaceutical, nutraceutical, and consumer wellness applications (Dewatisari & Nuryandani, 2025; Firmansyah et al., 2021; Permatasari et al., 2025; Rybarczyk, 2019). Despite its position as a dominant supplier of raw kratom leaf to international markets, Indonesia has historically captured only a small fraction of the value generated along the global kratom value chain, with most downstream processing into refined extracts occurring abroad and reflected in end-product prices several orders of magnitude higher than raw leaf prices. This pattern is symptomatic of a broader structural challenge in the Indonesian commodity export economy, where natural resource wealth is exported with minimal domestic value addition and the gains from processing accrue largely to foreign economies (Hendranata et al., 2004; Nugroho, 2021).

The Indonesian government has responded to this pattern through a national down streaming policy agenda that has been progressively extended across mineral, agricultural, and

botanical commodities (Kartikasari, 2024; Patunru, 2023; Suparman et al., 2026). In the kratom industry, the policy intervention took concrete form with the enactment of Permendag 20/2024 and Permendag 21/2024, which together took effect on 11 October 2024. The former prohibits the export of raw kratom leaf and coarsely processed material exceeding six hundred microns in particle size, while the latter establishes the regulated channel for processed kratom export through three instruments: Eksportir Terdaftar (Registered Exporter), Persetujuan Ekspor (Export Approval), and Laporan Surveyor (Surveyor Report). The combined effect of these regulations is to compel domestic processing of kratom into compliant downstream forms before any export can take place, thereby creating both an obligation and an opportunity for Indonesian firms to invest in pharmaceutical-grade extraction capacity.

The economic implications of this regulatory shift extend beyond compliance (Cordes et al., 2022; Folorunso et al., 2024; Ireland, 2024; Johnson, 2024). They raise a substantive question of whether domestic down streaming creates net value, both for the firms that invest in the required production capacity and for the Indonesian economy as a whole. The existing academic literature has examined kratom extensively from pharmacological, regulatory, and consumer-market perspectives, particularly in the United States and the European Union (Veltri & Grundmann, 2019; American Kratom Association, 2023). However, empirical economic analysis from the Indonesian production side, particularly of the firm-level financial feasibility and the macroeconomic linkage effects of domestic down streaming, remains underdeveloped. Most relevant studies tend to apply either a Cost-Benefit Analysis (CBA) framework for firm-level investment evaluation or an Input-Output (I-O) framework for macroeconomic impact assessment, but rarely both simultaneously.

There have been limited studies that combine these two analytical approaches in the context of Indonesian commodity down streaming policy. Joseph et al. (2020) conceptually argue that CBA and I-O analysis are mutually reinforcing rather than substitutional methods, but their integration in empirical work remains uncommon. Scandizzo (2021) and Boardman et al. (2018) provide methodological foundations for CBA in the development context, while Miller and Blair (2009) establish the modern foundations of input-output analysis. None of these works applies the integrated framework to a specific Indonesian botanical commodity under a recent regulatory transition. Therefore, this research intends to fill that empirical gap by applying an integrated CBA and I-O framework to the case of kratom down streaming in Indonesia, using primary pilot operational data from a Permendag 21/2024-compliant producer as the empirical foundation.

The objectives of this research are threefold: to assess firm-level financial feasibility, to quantify macroeconomic impact, and to derive strategic and policy implications from the integrated findings. This research offers theoretical, practical, and policy benefits. Theoretically, it contributes to down streaming literature by operationalizing an integrated CBA-I-O framework (Joseph et al., 2020) and extending input-output analysis to Indonesia's botanical sector. Practically, it provides firms with financial justification for downstream investment, pricing strategies, and risk insights. For policymakers, it offers evidence to support Permendag enforcement and extension to other commodities, along with sectoral multiplier insights. For the broader economy, it demonstrates how processed-export regulations translate into gains in output, employment, and foreign exchange, advancing the national down streaming agenda.

RESEARCH METHOD

This research adopted an integrated quantitative research design combining a firm-level Cost-Benefit Analysis with a national-level Input-Output Analysis, following the conceptual proposition of Joseph et al. (2020) that these two methods are mutually reinforcing rather than substitutional. The unit of analysis is PT MIT, a pseudonymous designation used to protect commercial confidentiality, representing an Indonesian kratom processing company that has completed pilot-scale production of Mit50 extract in compliance with Permendag 21/2024 quality specifications (minimum fifty percent *mitragynine* content, ninety-nine percent total alkaloids, particle size not exceeding six hundred microns). The analytical horizon is ten years.

Primary data were obtained from PT MIT through a formal data access meeting documented in a Minutes of Meeting dated 5 January 2026. Data categories include production parameters (yield rates, batch durations, quality specifications), cost structures (raw material procurement, processing chemicals and solvents, labour, facility overheads), capital expenditure itemization, and commercially validated transaction prices for Mit50 sold during the pilot period. Secondary data were drawn from the 2020 Indonesian Input-Output Table at the 185-product disaggregation level published by Badan Pusat Statistik (BPS), supplemented by macroeconomic data from Bank Indonesia, Ministry of Trade regulatory documents, sovereign rating reports from Standard & Poor's and Fitch Ratings, and international market data from Trading Economics.

The CBA was structured around three scenarios distinguished by steady-state capacity utilization: Conservative at seventy-five percent, Base Case at eighty-five percent, and Optimistic at ninety-three percent. All three scenarios share a uniform commercial selling price of USD 1,600 per kilogram of Mit50 (the validated pilot transaction price), a uniform total investment of Rp 9.00 billion (comprising Rp 6.00 billion in capital expenditure and Rp 3.00 billion in working capital), and a uniform discount rate of fifteen percent. The discount rate was derived through a build-up cost-of-capital approach combining a risk-free rate of 6.5 percent based on the Indonesian 10-year government bond yield, a mature-market equity risk premium of 4.21 percent from Damodaran (2025), a country risk premium of 3.5 percent reflecting Indonesia's BBB sovereign rating, and a project-specific premium of 1 to 2 percent. The financial evaluation computed six standard metrics: Net Present Value (NPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), Profitability Index (PI), discounted payback period, and Multiple on Invested Capital (MOIC). A nine-parameter one-way tornado sensitivity analysis and break-even analysis were also conducted.

The Input-Output Analysis mapped kratom extraction to Sector 105 (Produk Farmasi) of the 2020 BPS table. Type I multipliers for output (M_O), household income (M_I), and value added (M_VA) were computed from the Leontief inverse matrix using the standard formulae of Miller and Blair (2009). The Index of Backward Linkage (IBL) and Index of Forward Linkage (IFL) were computed as ratios of sector-specific linkage values to economy-wide averages, with values above unity indicating above-average linkage. The economy-wide impact estimates were derived by applying multipliers to the projected direct output at base case Year 4 steady state. Methodological limitations acknowledged include the sectoral aggregation of Sector 105, the single-firm scope, the six-year gap between the I-O reference year and the analytical horizon, and the limited regulatory implementation track record of Permendag 20/2024 and 21/2024.

RESULTS AND DISCUSSION

The findings are organized around three thematic clusters: firm-level financial feasibility results, sensitivity and break-even robustness analyses, and macroeconomic impact estimates. The Cost-Benefit Analysis results indicate that the kratom down streaming investment is financially feasible across all three scenarios. Table 1 summarizes the principal financial metrics.

Table 1. Cost-Benefit Analysis Results Across Three Scenarios

Financial Metric	Conservative (75%)	Base Case (85%)	Optimistic (93%)	Hurdle
Net Present Value (Rp billion)	2.33	**11.80**	17.49	> 0
Internal Rate of Return (%)	19.05	**37.59**	48.77	> 15%
Profitability Index (x)	1.26	**2.31**	2.94	> 1
Discounted Payback (years)	8.85	**4.88**	3.94	< 10
MIRR (%)	17.21	**25.05**	28.11	> 15%
MOIC (x)	3.25	**5.10**	6.31	> 2

Source: Authors' calculations based on PT MIT pilot operational data

The base case at eighty-five percent steady-state utilization generates an NPV of Rp 11.80 billion, an IRR of 37.59 percent against the fifteen-percent hurdle, a PI of 2.31, and a discounted payback of 4.88 years. The conservative scenario at seventy-five percent still produces a positive NPV of Rp 2.33 billion and an IRR of 19.05 percent, exceeding the discount rate by approximately four percentage points. The MIRR of 25.05 percent under base case conditions, computed under the more conservative assumption that interim cash flows are reinvested at the firm's cost of capital, remains comfortably above the hurdle rate. The MOIC of 5.10 times confirms that the project returns more than five times the invested capital over the ten-year horizon.

The sensitivity analysis enriches this conclusion by identifying which parameters most strongly drive NPV variation around the base case. Table 2 presents the nine-parameter tornado results. The Mit50 selling price is the single most material driver with a total NPV swing of Rp 39.69 billion, followed by variable cost (Rp 19.73 billion), production volume (Rp 19.71 billion), fixed operating expenses (Rp 11.69 billion), and chemicals cost per kilogram of Mit50 (Rp 7.54 billion). These findings are visually presented in Figure 1 (NPV tornado) and Figure 2 (IRR tornado).

Table 2. Sensitivity Analysis — NPV Swing by Parameter (Base Case = Rp 11.80 billion)

No.	Parameter	Downside (Rp B)	Upside (Rp B)	Total Swing (Rp B)
1	Selling price (USD/kg Mit50)	-20.26	+19.43	**39.69**
2	Variable cost of goods sold	-10.01	+9.72	**19.73**
3	Production volume (kg/month)	-10.00	+9.71	**19.71**
4	Fixed operating expenses	-5.97	+5.72	**11.69**
5	Chemicals cost (per kg Mit50)	-3.82	+3.72	**7.54**

6	Discount rate (WACC ±3pp)	-2.57	+3.13	**5.70**
7	Kratom leaf procurement price	-2.18	+2.14	**4.32**
8	Initial capital expenditure	-1.04	+1.04	**2.08**
9	Working capital requirement	-0.60	+0.60	**1.20**

Source: Authors' calculations.

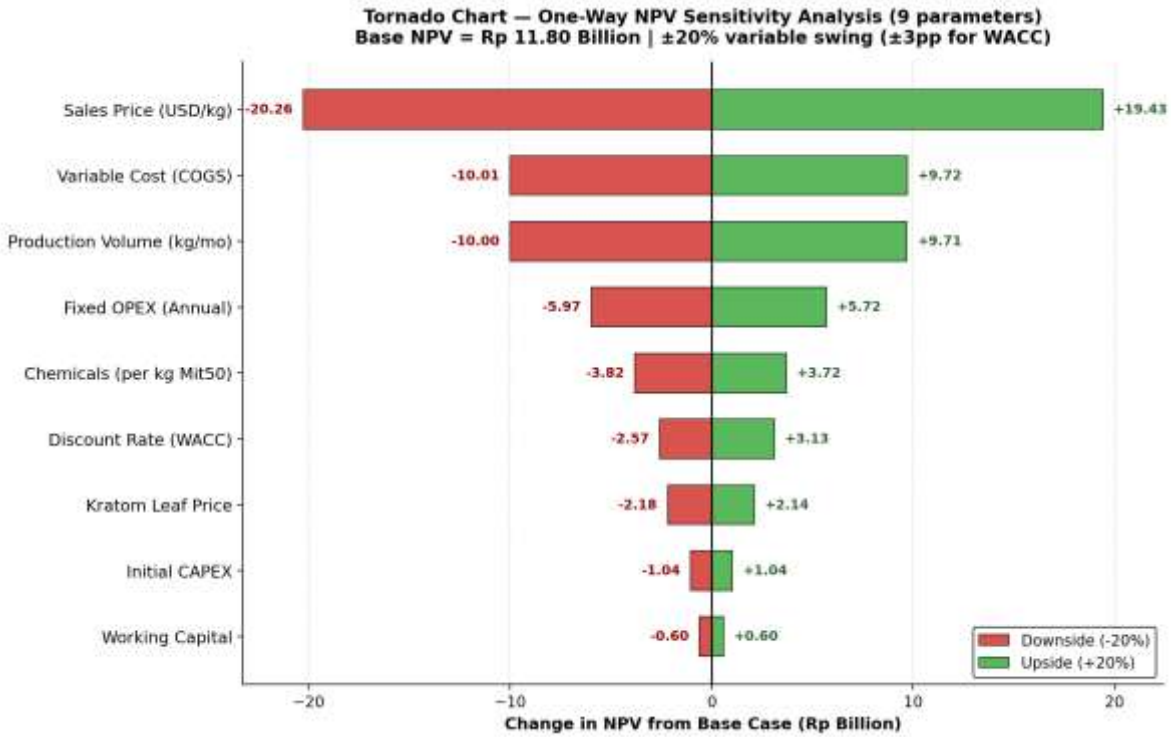

Figure 1. Tornado Chart — One-Way NPV Sensitivity Analysis (9 Parameters, Base NPV = Rp 11.80 billion)

Source: Authors' calculations.

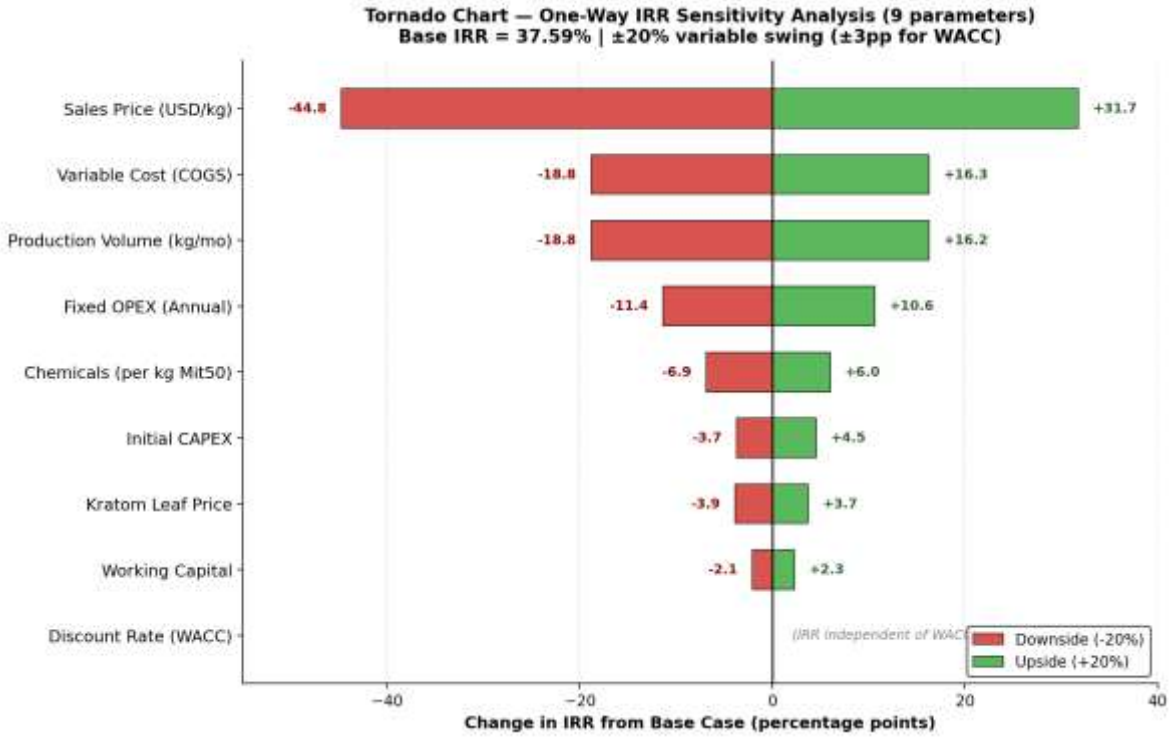

Figure 2. Tornado Chart — One-Way IRR Sensitivity Analysis (9 Parameters, Base IRR = 37.59%)

Source: Authors' calculations.

The tornado charts confirm the dominance of the selling price as the top value driver in both NPV and IRR dimensions, with an IRR swing of 76.5 percentage points under the plus or minus twenty percent price test. The break-even analysis establishes that the investment remains NPV-positive down to a capacity utilization of 44.74 percent (relative margin of safety 47.36 percent from the base case) and a selling price of USD 1,410 per kilogram (11.9 percent below the validated pilot price). Variable costs can rise by approximately 21.7 percent before the investment reaches break-even. These wide margins of safety indicate robustness to the kinds of operational and market disturbances typical of early-commercial pharmaceutical-grade extraction.

The Input-Output Analysis indicates that Sector 105 (Pharmacy Product) functions as a strong demand-pull sector in the Indonesian economy. The Type I output multiplier is 1.7433 (ranked 70th out of 185 sectors), the household income multiplier is 0.2919, and the value-added multiplier is 0.8159. The Index of Backward Linkage is 1.0731, exceeding the threshold of unity that qualifies the sector as a strong demand-pull driver. Table 3 summarizes these indicators.

Table 3. Input-Output Multipliers and Linkage Indices — Sector 105 (Pharmaceutical Products)

Indicator	Sector 105 Value	Economy Avg.	Rank/Status
Output Multiplier (M_O)	1.7433	1.6245	70 / 185
Household Income Multiplier (M_I)	0.2919	—	—
Value-Added Multiplier (M_VA)	0.8159	—	—
Index of Backward Linkage (IBL)	1.0731	1.0000	Strong demand-pull

Index of Forward Linkage (IFL)	0.8368	1.0000	Below average

Source: Authors' calculations using the 2020 BPS Indonesian Input-Output Table at 185-product disaggregation.

Applying these multipliers to the base case Year 4 steady-state direct output of approximately Rp 27.74 billion yields a total annual output impact of approximately Rp 48.37 billion, comprising Rp 27.74 billion direct and Rp 20.62 billion indirect. The annual value added generated is approximately Rp 22.64 billion. Household income attributable to the investment is approximately Rp 8.10 billion per year. Direct employment of fifty workers at PT MIT is amplified by indirect employment of approximately forty-three to forty-five workers in upstream supplier industries, yielding a total footprint of approximately ninety-three to ninety-five jobs per year. Foreign exchange contribution averages approximately USD 1.53 million per year over the ten-year horizon.

The integration of the firm-level and macroeconomic findings yields three principal implications. First, theoretically, this study operationalizes the conceptual proposition of Joseph et al. (2020) that CBA and I-O analysis are mutually reinforcing, demonstrating that their joint application illuminates value-creation dynamics that neither method alone could reveal. Second, managerially, PT MIT and similar firms should prioritize pricing discipline as the highest-order strategic capability, given that the Mit50 selling price is the single most material driver of firm-level value; the practical recommendation is to negotiate multi-year contracts at or above USD 1,500 per kilogram. Third, for policy, the Permendag 20/2024 and 21/2024 regulatory framework has created conditions under which both private and social returns to investment can be realized simultaneously, providing empirical support for the broader Indonesian down streaming agenda.

CONCLUSION

This study has applied an integrated Cost-Benefit Analysis and Input-Output Analysis framework to the case of kratom down streaming in Indonesia, using validated pilot operational data from PT MIT as the empirical foundation. The findings show that the investment in pharmaceutical-grade Mit50 production at a commercial scale of one hundred kilograms per month is financially feasible across conservative, base, and optimistic scenarios, with the base case generating an NPV of Rp 11.80 billion, an IRR of 37.59 percent against a fifteen-percent discount rate, and a discounted payback of 4.88 years. The sensitivity and break-even analyses establish robustness to substantial operational variation. The macroeconomic impact analysis shows that the sector to which kratom extraction is mapped is a strong demand-pull driver in the Indonesian economy, with an output multiplier of 1.7433 and a backward linkage index of 1.0731. The investment generates total economy-wide output of Rp 48.37 billion per year at base case steady state, supports approximately ninety-three jobs, and contributes approximately USD 1.53 million in foreign exchange per year. These macroeconomic benefits demonstrate that domestic down streaming aligns private profitability with broader national development objectives. The principal contribution of this study lies in demonstrating, through an empirically grounded integrated analytical framework, how a regulatory shift toward processed-export requirements translates into measurable private and social returns. For PT MIT and similar firms, the recommendation is to proceed with the investment and prioritize

pricing discipline through multi-year contracts. For Indonesian policymakers, the findings provide quantitative evidence that the Permendag framework delivers both compliance and economic gains, supporting its continued enforcement and extension to other botanical commodities. Future research directions include disaggregation of Sector 105, multi-firm empirical extension, and longitudinal observation of regulatory implementation outcomes.

REFERENCE

American Kratom Association. (2023). *Kratom consumer protection: Industry report 2023*. American Kratom Association. https://www.americankratom.org

Boardman, A. E., Greenberg, D. H., Vining, A. R., & Weimer, D. L. (2018). *Cost-benefit analysis: Concepts and practice* (5th ed.). Cambridge University Press.

Cordes, J. J., Dudley, S. E., & Washington, L. (2022). *Regulatory compliance burdens*. GW Regulatory Studies Center.

Damodaran, A. (2025). *Country risk: Determinants, measures and implications—The 2025 edition*. NYU Stern School of Business. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5354459

Dewatisari, W. F., & Nuryandani, E. (2025). A review on alkaloid diversity in *Mitragyna speciosa* (kratom): Influence of strain and geographic origin. *Proceeding International Seminar of Science and Technology, 4*, 49–62.

Firmansyah, A., Sundalian, M., & Taufiq, M. (2021). Kratom (*Mitragyna speciosa* Korth.) for a new medicinal: A review of pharmacological and compound analysis. *Biointerface Research in Applied Chemistry, 11*(2), 9704–9718.

Folorunso, A., Wada, I., Samuel, B., & Mohammed, V. (2024). Security compliance and its implication for cybersecurity. *World Journal of Advanced Research and Reviews, 24*(1), 2105–2121.

Hendranata, A., Brodjonegoro, B. P. S., & Sinaga, B. M. (2004). The econometric input-output approach for analysing fiscal policy impacts in Indonesia. *Journal of Indonesian Economy and Business, 19*(3), 245–266.

Ireland, D. (2024). *Behavioral economics, regulatory compliance and performance, and the compliance continuum*. SSRN.

Johnson, G. A. (2024). Economic research on privacy regulation: Lessons from the GDPR and beyond. In *The economics of privacy* (pp. 97–126). University of Chicago Press.

Joseph, C., Gunton, T., Knowler, D., & Broadbent, S. (2020). The role of cost-benefit analysis and economic impact analysis in environmental impact assessment. *Impact Assessment and Project Appraisal, 38*(3), 197–207.

Kartikasari, F. I. (2024). *Mining and environmental protection in Indonesia: Regulator pitfalls.*

Miller, R. E., & Blair, P. D. (2009). *Input-output analysis: Foundations and extensions* (2nd ed.). Cambridge University Press.

Nugroho, A. E. (2021). Industrial downstream policy in Indonesia: An assessment of mineral commodity programs. *Mineral Economics, 34*(2), 215–229.

Patunru, A. A. (2023). Trade policy in Indonesia: Between ambivalence, pragmatism and nationalism. *Bulletin of Indonesian Economic Studies, 59*(3), 311–340.

Permatasari, H. K., Nugrahenny, D., Lestari, B., Hakim, R. W., Zulkarnain, Z., Anshory, M., & Nurkolis, F. (2025). Kratom (*Mitragyna speciosa*) in cancer chemoprevention: A provocative functional food perspective. *Journal of Agriculture and Food Research*, *102525*.

Rybarczyk, K. S. (2019). *Quantitative analysis of mitragynine in consumer products labeled as kratom* (Master's thesis). University of Illinois at Chicago.

Scandizzo, P. L. (2021). *Cost-benefit analysis: A pragmatic approach*. Edward Elgar

Publishing.
Suparman, N., Septiadi, M. A., Timoty, Y. R., & Pikri, F. (2026). Regulatory hierarchy conflicts and the regional autonomy regime in bauxite mining management in Indonesia. *Journal of Mining and Environment, 17*(1), 89–104.
Veltri, C., & Grundmann, O. (2019). Current perspectives on the impact of kratom use. *Substance Abuse and Rehabilitation, 10*, 23–31.