JOURNAL OF MARITIME RESEARCH

Vol XXIII. No. II (2026) pp 431–436

**ISSN: 1697-4840, www.jmr.unican.es**

# Green Productivity Measurement Based on Environmental Performance Indicators in Optimizing the Performance of Fish Processing MSMEs

Wiwin Sri Lestari[1], M. Imron Mas'ud[1,*]

*ARTICLE INFO*

***Article history:***
Received 23 Jul 2025;
in revised form 16 Aug 2025;
accepted 15 Oct 2025.

***Keywords:***
Green Productivity, Environmental Performance Indicators, Fish Processing, MSMEs, Sustainability.

*ABSTRACT*

This research will assess Green Productivity (GP) by integrating Environmental Performance Indicators (EPI) to improve the performance of a fish-processing MSME in Pasuruan Regency, Indonesia. Primary data were collected by observations, interviews, and questionnaires. Secondary data were logs of utility usage and internal reports. This research utilized the Input–Process–Output–Outcome (IPOO) framework and the PDCA cycle. The results of this research demonstrated a revenue of IDR 150 million per month with an overall score of economic efficiency that is considered high at 2.21. However, this enterprise produces 4,015 kg $CO_2$e every month as a result of the emissions from electricity, LPG, water, and organic waste. The EPI was measured at IDR 37,368 per kg $CO_2$e and the GP index was measured at 0.00055, also indicating low Eco-efficiency. The main innovation of this research lies in the integration of GP and EPI in MSMEs using real emissions-based indicators in order to detect inefficiencies and develop green solutions. Some of the expected results include a structured assessment framework of MSMEs; supportive green policies; and the promotion of advanced green business practices, lowering the cost of sustainable operations. Among other suggested improvements are more energy efficient technologies, waste composting, water reuse, and staff training. This research shows that environmental indicators boost MSMEs in the traditional sector's green competitiveness.



## 1. Introduction.

In the current fast-moving world economy, the protection of the environment is an issue spanning the culinary and fish processing fields, as it does for most other industries. GP seeks to strike a balance between the economy and the environment by cutting waste and achieving greater resource efficiency. (Ibidhi & Ben Salem, 2020; Lin & Bhardwaj, 2020; Mas'ud et al., 2022a).

This approach sees that productivity gains should not come at the expense of ecological deterioration, but should promote goals of sustainable development. (Hutagalung, 2020; Mas'ud et al., 2022a).

The utility of GP is furthered by the Environmental Performance Indicators (EPI) whose role is to evaluate and assess the overall impact of business operations on the environment. These assess the balance the business has between economic activity and ecological impact by assessing indicators including energy use, water use, waste generated, and the emission of greenhouse gases. (Hutagalung, 2020; Mas'ud et al., 2022a; Prasetia, 2024).

Through the integration of EPI within GP measurement, even the smallest of businesses can assess and improve their activities. (Lin & Bhardwaj, 2020; Silaban et al., 2025).

Indonesia's MSMEs are an important driver of the economy and jobs, but have fallen short of their responsibility to promote environmental sustainability due to limited green technologies, poor environmental management, and operational inefficiencies. (Mas'ud, Zahro, et al., 2025). This is especially true of MSME food processors which consume large amounts of energy and water while producing unmanaged organic waste.

[1]Department of Industrial Engineering, Faculty of Engineering, Universitas Yudharta Pasuruan, Pasuruan, Indonesia.
[*]Corresponding author: M. Imron Mas'ud. E-mail Address: imron@yudharta.ac.id.

(Azis, 2023; Fahrul Rozi Adami Nasution et al., 2023).

This study focuses on a traditional fish processing restaurant based in Pandaan District, Pasuruan Regency. This MSME is situated within the culinary sector with a daily service and traditional processing. Despite the effectiveness of the business' natural dining concept and its associated local menu, the business has challenges related to high energy use, inefficient water use, and poor waste management. All of these negatively impact the environment and contribute to an unmeasured and unmanaged environmental footprint (Halim, 2020; Mas'ud, Alviansyah, et al., 2025; Sarfiah et al., 2019; Yudhanto et al., 2023).

Currently, the absence of environmental impact assessment frameworks (EPI) and institutionalized green operational strategies constrain long-term business sustainability. It has been documented that bringing together Green Productivity and EPI within MSMEs has the potential to decrease emissions and enhance positive resource management, especially in markets that value environmental protection. (Fahrul Rozi Adami Nasution et al., 2023; Fitri et al., 2024; Hutagalung, 2020).

The aim is to use the Green Productivity framework with Environmental Performance Indicator to analyze and enhance the operations of a fish-based MSME in Pandaan. Based on the findings, it is hoped to create a model for assessing sustainability for other MSMEs in similar sectors to encourage localized circular economy and green business environment. (Goshu et al., 2017; Katili et al., 2021; Mas'ud et al., 2022b; Prasetia, 2024; SHI et al., 2020; Tian & Liu, 2021).

## 2. Materials and Methods.

### *2.1. Research Design.*

This study adopts a quantitative-descriptive approach to evaluate how Green Productivity (GP) can be implemented by using Environmental Performance Indicators (EPI) to analyze and improve environmental and operational performance of fish-based MSMEs. (Conference et al., 2020; Kulsum et al., 2022; Pradana et al., 2018; Silaban et al., 2025). The descriptive nature of this study allows for a systematic and objective identification of sustainability gaps in resource consumption, waste generation, and production efficiency. The operational processes of a fish-based restaurant in the district of Pandaan, which is a representative fish-based MSME in Pasuruan Regency, is the unit of analysis. (Cunbao et al., 2011; Liu et al., 2019; Mullon et al., 2017).

### *2.2. Conceptual Framework.*

The Green Productivity and EPI based optimization Input-Process-Output-Outcome (IPOO) frame work is used as the research framework. Inputs consist of material resources, energy, labor, policies, and environmental awareness. The Process dimension suggests measurement of EPI indicators, energy, water, waste and carbon emissions, and their relationships with Green Productivity. Outcomes are expressed through the long term performance of Green Productivity, and competitiveness of MSME. (Azis, 2023; Lin & Bhardwaj, 2020; Mas'ud et al., 2022a; Pradana et al., 2018).

### *2.3. Data Collection.*

Data hampered observation of the production process and the use of energy, water and the removal of waste. Semi structured interviews were used to elicit perceptions and measures of GP and EPI. A questionnaire was used to evaluate stakeholder perceptions of environmental management and green operation. (Deros et al., 2015).

Observation of the production process was performed to capture the use of energy and water, and the management of waste. Semi-structured interviews of the owners, managers and staff were performed to capture their GP and EPI awareness and practice. Furthermore, a questionnaire was constructed to assess the environmental and green operations management of stakeholders.. (Hanik & Mas'ud, 2019; Imron Rosadi et al., 2019; Mas'ud, 2022a, 2022b; Mas'ud et al., 2022b; Mas'ud & Wahid, 2022).

### *2.4. Data Analysis Method.*

#### *2.4.1. Green Productivity (GP) Measurement.*

GP is measured using the formula:

$$\text{Green Productivity} = \frac{\text{Output}}{\text{Input} \times \text{Environmental Impact}}. \quad (1)$$

Where:

- Output refers to economic performance (revenue or volume produced),
- Input includes material, labor, energy, and water,
- Environmental impact is measured by EPI scores.

This equation provides a capability to compute productivity while accounting for environmental burden and therefore promotes resource efficiency and emission reduction. (Rawat et al., 2018; Salehi et al., 2013; Tian & Liu, 2021).

#### *2.4.2. Environmental Performance Indicator (EPI) Evaluation.*

EPI assessment incorporates several sub-indicators:

- Energy Efficiency Indicator (EEI) = Energy used per unit of output (kWh/unit),
- Water Efficiency Indicator (WEI) = Water used per unit of output (L/unit),
- Waste Generation Rate = kg of solid/liquid waste per unit of output,
- Carbon Emission Estimate = Emissions per production cycle (kg $CO_2$/unit).

Each indicator is evaluated against benchmarks or industry standards using scoring and weighting systems to derive an aggregated EPI score. The EPI value <100% indicates better-than-standard performance, while >100% signals environmental inefficiency (Azis, 2023; Fahrul Rozi Adami Nasution et al., 2023; Fitri et al., 2024; Hutagalung, 2020; Pradana et al., 2018).

*2.4.3. Optimization Strategy.*

The optimization strategy follows the Continuous Improvement (CI) cycle using the PDCA (Plan–Do–Check–Act) method (De Barros et al., 2021; Markert et al., 2017; Pereira et al., 2019; Trubetskaya et al., 2022; Uddin, 2021). Simulations and improvement plans are proposed to reduce environmental impacts while maintaining or increasing productivity. Emphasis is placed on identifying resource-intensive stages and implementing low-cost, high-impact eco-innovations (Copena et al., 2022; Ermolaev et al., 2019; Gitelman et al., 2019).

*2.5. Expected Outcomes.*

The expected outcomes of this research are a quantitative Green Productivity index as a performance benchmark. A diagnostic evaluation of EPI performance to identify sustainability gaps and resource inefficiencies. Strategic recommendations to optimize MSME operations through green innovation and environmental stewardship (Azis, 2023; Fahrul Rozi Adami Nasution et al., 2023; Kulsum et al., 2022).

## 3. Result and Discussion.

The case enterprise is a fish-processing MSME located in Pasuruan Regency that operates with a traditional culinary concept and serves approximately 150 customers per day. It employs 15 staff and runs 30 days per month with 8 working hours per day. Despite its financial sustainability, the enterprise has significant issues with operational inefficiency, namely with the use of energy and water, and the generation of waste. These issues illustrate the need for an assessment based on Green Productivity (GP) and Environmental Performance Indicators (EPI) to facilitate sustainable development.

*3.1. Results.*

*3.1.1. Data Operational Data Summary.*

Monthly operational data indicated a total income of IDR 150,000,000 with a total of 3,600 labor hours. Inputs consisted of raw materials worth IDR 50,000,000, electricity consumption of 2,000 kWh, and consumption of LPG and water where 50 cylinders and 100 $m^3$ were used respectively. Organic waste was generated at 510 kg/month mainly from food waste and scraps and preparation waste. Other operating costs including supplies for cleaning and packing were IDR 7,500,000. The data collected was the basis for the assessment of productivity, environmental impact, and green productivity.

*3.1.2. Productivity Analysis.*

The total monthly input cost was IDR 68,000,000, consisting of:

- Raw materials: IDR 50,000,000
- Electricity: 2,000 kWh × IDR 1,500 = IDR 3,000,000
- LPG: 50 × IDR 150,000 = IDR 7,500,000
- Other operational costs: IDR 7,500,000

$$\text{Productivity} = \frac{150{,}000{,}000}{68{,}000{,}000} = 2.21. \quad (2)$$

This shows each unit of input cost generated output worth IDR 2.21, therefore, good economic efficiency.

*3.1.3. Environmental Impact Conversion.*

Environmental impacts have been converted to $CO_2$ equivalent (kg $CO_2$e) based on emission factors that are operational.

Table 1: Environmental impact conversion by component.

| Component | Quantity | Emission Factor | Emissions (kg $CO_2$e) |
|---|---|---|---|
| Electricity | 2,000 kWh | 0.85 kg/kWh | 1,700 |
| LPG | 600 kg | 2.5 kg/kg LPG | 1,500 |
| Organic Waste | 510 kg | 1.5 kg/kg waste | 765 |
| Clean Water | 100 $m^3$ | 0.5 kg/$m^3$ | 50 |
| Total | — | — | 4,015 kg $CO_2$e |

Source: Authors.

*3.1.4. Environmental Performance Indicator (EPI).*

$$\text{EPI} = \frac{150{,}000{,}000}{4{,}015} = 37{,}368.01 \text{ IDR/kg } CO_2\text{e}. \quad (3)$$

It is worth mentioning that each kilogram of $CO_2$e (i.e., each unit of environmental impact) contributes IDR 37,368 to the economy. This means that the enterprise is currently efficient to the moderately optimal level. However, this shows that the current level of environmental efficiency can be improved.

*3.1.5. Green Productivity Index.*

The Green Productivity index combines productivity and environmental performance:

$$\text{GP} = \frac{2.21}{4{,}015} = 0.00055. \quad (4)$$

The low value shows the enterprise has a relatively large environmental burden and points to a need for better environmental management.

*3.2. Discussion.*

*3.2.1. Economic Productivity.*

In alignment with existing studies, the productivity score demonstrates effective use of resources to generate revenue by optimizing labor and raw materials. High productivity, however, will not guarantee long-term sustainability without consideration for the environment.

Table 2: Key Indicators.

| Indicator | Value | Interpretation |
|---|---|---|
| Economic Productivity | 2.21 | High productivity efficiency |
| Total Environmental Impact | 4,015 kg $CO_2e$ | Significant burden |
| EPI | IDR 37,368/kg $CO_2e$ | Moderate efficiency |
| Green Productivity Index | 0.00055 | Low—improvement required |

Source: Authors.

*3.2.2. Environmental Performance.*

The EPI score suggests that the enterprise is producing considerable emissions relative to its economic output. This score is rather moderate and indicates opportunities for advancement in waste recovery and clean energy.

*3.2.3. Green Productivity.*

Low GP indicates the imperative need for conservation and waste management interventions. Studies support that by implementing green innovations such as use of renewable energy sources or organic waste composting significant improvements will be observed for GP scores.

*3.2.4. Root Cause Analysis.*

Table 3: Root Cause Analysis.

| Challenge | Cause | Recommendation |
|---|---|---|
| High conventional energy usage | Use of LPG and standard electrical appliances | Transition to energy-efficient appliances and biogas |
| Organic waste mismanagement | No composting or waste sorting | Install composting unit and partner with waste banks |
| Water inefficiency | No reuse or recycling system | Implement greywater reuse for gardening or toilets |
| Lack of SOP and training | No green standard procedures or employee education | Develop SOPs and training for sustainability |

Source: Authors.

*3.2.5. Strategic Improvement Plan.*

To improve GP and EPI, the following green strategies are suggested:

- Energy Optimization: Use induction cooktops and LED lighting, monitor energy use with audits.
- Waste Recovery: Collaborate with local recycling entities and compost kitchen waste.
- Water Conservation: Save wash water, raise staff awareness, implement targets for water use.
- Behavioral Change: Create green SOPs, provide incentives to motivate sustainable behavior.

*3.2.6. Implications.*

- Practical Implication: Provides a measurement framework and actionable roadmap for MSMEs to implement green principles.
- Academic Implication: Adds to the GP-EPI modeling in micro-scale food enterprises.
- Policy Implication: Provides support to green MSME incentives offered by policymakers which include tax relief or subsidized technologies.

## 4. Conclusions.

This paper suggests that integrating Green Productivity (GP) and Environmental Performance Indicators (EPI) is an efficient way to assess the balance of economic performance and environmental impact for fish-processing MSMEs. It is found that the MSME has an economic productivity score of 2.21, meaning that for every one unit of IDR spent on operational input, it generates a revenue of IDR 2.21, indicating strong economic performance. However it reports a total environmental burden of 4,015 kg of $CO_2$ equivalent per month, mainly attributable to energy (electricity and LPG) consumption, organic waste, and water use. This large environmental burden negatively impacts the sustainability of the process.

The Environmental Performance Indicator (EPI) was recorded at IDR 37,368.01 per kg $CO_2e$, showing moderate environmental performance. While the enterprise can potentially convert environmental burden to economic value, the level is not optimal. The Green Productivity Index (GP) was calculated to give a value of 0.00055, reflecting low environmentally sustainable productivity. This means that while the MSME has financial success, it lacks environmental performance. Many factors attributed to the low GP including no energy-saving devices used for fossil-fuel energy, no organic waste management system, no water use technologies for reuse, no green operational standards, and low sustainability awareness of employees.

## 5. Recommendations.

We propose layers upon layers of environmental and economic improvements. First, improve energy efficiency by upgrading from LPG to electric cookers and biogas systems and using lights and appliances that have energy-saving certificates. We recommend a monthly energy audit to limit how much energy we use. Next, we recommend collecting organic waste and transforming it into compost for use onsite or for sale. This may also attract farmers and waste banks to collaborate with us. Lastly, we recommend gray water (used during dishwashing) for irrigation and toilet flushing. We recommend simple water filtration systems and education for employees for this to be successful.

Fourth, it is important to create and utilize 'green' standard operating procedures (SOPs) that help promote best environmental practices such as waste segregation and energy saving,

and also the principles of 3R (Reduce, Reuse, Recycle). Sustainability training should be offered to employees on a regular basis, and a reward system should be put into place in order to motivate employees to engage in 'green' behavior. Finally, we recommend that MSMEs perform frequent assessments of their GP and EPI scores to better understand their status and to identify areas for improvement. These changes will have a positive impact on the performance of the business.

## References


Azis, A. M. (2023). Analisis Penerapan Metode Green Productivity dalam Meningkatkan Produktivitas dan Lingkungan. *Jurnal Bisnis Dan Kajian Strategi Manajemen*, *7*(2), 180–193. https://doi.org/10.35308/jbkan.v7i2.8118.

Conference, P. I., Volume, G. A., & Revolution, T. I. (2020). *Farming in the Era of Industrial Revolution 4 . 0 : The Environmental Challenges*. *4*, 27–38. http://eprints.upnyk.ac.id/22872/1/4. Partoyo.pdf

Copena, D., Pérez-Neira, D., Macías Vázquez, A., & Simón, X. (2022). Community forest and mushrooms: Collective action initiatives in rural areas of Galicia. *Forest Policy and Economics*, *135*. https://doi.org/10.1016/j.forpol.2021.102660.

Cunbao, M., Zi, G., & Lin, Y. (2011). Safety analysis of airborne weather radar based on failure mode, effects and criticality analysis. *Procedia Engineering*, *17*(Isaa), 407–414. https://doi.org/10.1016/j.proeng.2011.10.048.

De Barros, L. B., Bassi, L. de C., Caldas, L. P., Sarantopoulos, A., Zeferino, E. B. B., Minatogawa, V., & Gasparino, R. C. (2021). Lean healthcare tools for processes evaluation: An integrative review. *International Journal of Environmental Research and Public Health*, *18*(14). https://doi.org/10.3390/ijerph18147389.

Deros, B. M., Hassan, N. H. H., Daruis, D. D. I., & Tamrin, S. B. M. (2015). Incorporating Malaysian's Population Anthropometry Data in the Design of an Ergonomic Driver's Seat. *Procedia - Social and Behavioral Sciences*, *195*, 2753–2760. https://doi.org/10.1016/j.sbspro.2015.06.388.

Ermolaev, E., Lalander, C., & Vinnerås, B. (2019). Greenhouse gas emissions from small-scale fly larvae composting with Hermetia illucens. *Waste Management*, *96*, 65–74. https://doi.org/10.1016/j.wasman.2019.07.011.

Fahrul Rozi Adami Nasution, Meri Andriani, & Yusnawati. (2023). Peningkatan Produktivitas Dengan Metode Green Productivity Pada PT. Bangun Tenera Riau Desa Pantai Raja Kabupaten Kampar. *Jurnal Ilmiah Teknik Industri Dan Inovasi*, *1*(4), 1–11. https://doi.org/10.59024/jisi.v1i4.462.

Fitri, L., Syakhroni, A., & Bernadhi, B. D. (2024). Usulan Penerapan Green Productivity Pada Proses Produksi Tahu (Studi Kasus : Ud Tahu Pak Mat Rodli). *Jurnal Logistica*, *3*(1), 6–9. https://doi.org/10.62375/logistics.v3i1.373.

Gitelman, L., Magaril, E., Kozhevnikov, M., & Rada, E. C. (2019). Rational behavior of an enterprise in the energy market in a circular economy. *Resources*, *8*(2). https://doi.org/10.3390/resources8020073.

Goshu, Y. Y., Matebu, A., & Kitaw, D. (2017). Development of Productivity Measurement and Analysis Framework for Manufacturing Companies. *Journal of Optimization in Industrial Engineering*, *10*(22), 1–13. https://doi.org/10.22094/joie.2017.274.

Halim, A. (2020). Pengaruh Pertumbuhan Usaha Mikro, Kecil Dan Menengah Terhadap Pertumbuhan Ekonomi Kabupaten Mamuju. *Jurnal Ilmiah Ekonomi Pembangunan*, *1*(2), 157–172. https://stiemmamuju.e-journal.id/GJIEP/article/view/39.

Hanik, U., & Mas'ud, M. I. (2019). Perencanaan Inovasi Pengembangan Agrowisata Bukit Flora Dengan Pendekatan Metode Bisnis Model Kanvas. *JKIE (Journal Knowledge Industrial Engineering)Journal Knowledge Industrial Engineering*, *6*(3), 81–90. https://doi.org/10.35891/jkie.v6i3.2088.

Hutagalung, I. G. V. (2020). Perbaikan Produktivitas melalui Green Productivity. *Journal of Industrial View*, *2*(1), 27–32. https://doi.org/10.26905/jiv.v2i1.4210.

Ibidhi, R., & Ben Salem, H. (2020). Water footprint and economic water productivity assessment of eight dairy cattle farms based on field measurement. *Animal*, *14*(1), 180–189. https://doi.org/10.1017/S1751731119001526.

Imron Rosadi, M., Faris, Ahwan, Z., & Mulyono, W. (2019). Modernisasi Manajemen Bank Sampah Melalui Pemanfaatan Aplikasi Bank Sampah IT Mobile Pada Komunitas Bank Sampah TPI BISA Kelurahan Pagak Kecamatan Beji Kab. Pasuruan. *JURNAL SOEROPATI*, *2*(November), 1–18.

Katili, P. B., Gunawan, A., Damayanti, U., Kulsum, K., & Kurniawan, B. (2021). Analisis Pengukuran Produktivitas Pt Xyz Menggunakan Metode American Productivity Center Dan Craig-Harris. *Journal Industrial Servicess*, *6*(2), 135. https://doi.org/10.36055/62009.

Kulsum, K., Sutanto, Y., Febianti, E., Trenggonowati, D. L., Wigati, R., Gunawan, A., & Kurniawan, B. (2022). Strategi peningkatan produktivitas dengan pendekatan green productivity pada agroindustri kedelai. *Journal Industrial Servicess*, *8*(1), 71. https://doi.org/10.36055/jiss.v8i1.14445.

Lin, C., & Bhardwaj, K. . (2020). Green Productivity for the SDGs: Review of Emerging and Priority Needs. *Asian Productivity Organization*, 50.

Liu, S., Bush, K. K., Bertini, J., Fu, Y., Lewis, J. M., Pham, D. J., Yang, Y., Niedermayr, T. R., Skinner, L., Xing, L., Beadle, B. M., Hsu, A., & Kovalchuk, N. (2019). Optimizing efficiency and safety in external beam radiotherapy using automated plan check (APC) tool and six sigma methodology. *Journal of Applied Clinical Medical Physics*, *20*(8), 56–64. https://doi.org/10.1002/acm2.12678.

Markert, B., Delakowitz, B., Fränzle, S., & Wünschmann, S. (2017). Quality means decency–on the quality of teaching through accreditation of the course? *Environmental Science and Pollution Research*, *24*(13), 11940–11948. https://doi.org/10.1007/s11356-015-5599-8.

Mas'ud, M. I. (2022). Pengukuran Produktivitas dengan Pendekatan Rasio Output Input di UD . X. *Seminar Nasional Teknologi Industri Berkelanjutan II (SENASTITAN II)*, *5*(I), 305–310.

Mas'ud, M. I., Alviansyah, M., Ghofur, M., Lestari, M. Y., Joyo, M. A., & Amir, S. (2025). Circular Economy Principles in Fish Restaurant MSMEs to Improve Operational Ef-

ficiency. *Journal of Maritime Research*, *XXII*(II), 303–307. https://www.jmr.unican.es/jmr/article/view/1098/1045.

Mas'ud, M. I., & Wahid, A. (2022). Model SMEs digital disruption management with business model canvas and integer programming. *International Journal of Trends in Mathematics Education Research*, *5*(2), 162–168. https://ijtmer.saintispub.-com/ijtmer/article/download/134/102.

Mas'ud, M. I., Wahid, A., Nuriyanto, Wibowo, M. M. A., & Pusakaningwati, A. (2022). Effectivity Green Productivity Basis Triple Helix in Tofu Central Industry. *Seybold Report*, *17*(8), 1024–1036. https://doi.org/10.5281/zenodo.7006265.

Mas'ud, M. I., Zahro, A., Airinazzahra, S. S., Ainurrohmah, H. S., & Zalki, I. A. (2025). Potential and Challenges of Increasing Productivity of Fishing MSMEs. *Journal of Maritime Research*, *XXII*(II), 354–357. https://www.jmr.unican.es/jmr/-article/view/1104/1051.

Mullon, C., Guillotreau, P., Galbraith, E. D., Fortilus, J., Chaboud, C., Bopp, L., Aumont, O., & Kaplan, D. (2017). Exploring future scenarios for the global supply chain of tuna. *Deep-Sea Research Part II: Topical Studies in Oceanography*, *140*, 251–267. https://doi.org/10.1016/j.dsr2.2016.08.004.

Pereira, A. M. H., Silva, M. R., Domingues, M. A. G., & Sá, J. C. (2019). Lean six sigma approach to improve the production process in the mould industry: A case study. *Quality Innovation Prosperity*, *23*(3), 103–121. https://doi.org/10.12776/QIP.V23I3.1334.

Pradana, T. A., Leksono, E. B., & Andesta, D. (2018). Usulan Implementasi Green Productivity Untuk Meningkatkan Produktivitas Dan Kinerja Lingkungan Di Pt Samator Intiperoksida. *Matrik: Jurnal Manajemen Dan Teknik Industri Produksi*, *17*(2), 21–28.

Prasetia, B. (2024). Green Productivity Techniques for Analyzing Productivity in Agroindustry. *Tarjih : Agribusiness Development Journal*, *4*(01), 24–30. https://doi.org/10.47030/tadj.v4i01.761.

Rawat, G. S., Gupta, A., & Juneja, C. (2018). Productivity Measurement of Manufacturing System. *Materials Today: Proceedings*, *5*(1), 1483–1489. https://doi.org/10.1016/j.matpr.2017.11.237.

Salehi, M., Shirouyehzad, H., & Dabestani, R. (2013). Labour productivity measurement through classification and standardisation of products. *International Journal of Productivity and Quality Management*, *11*(1), 57–72. https://doi.org/10.1504/IJPQM.2013.050568.

Sarfiah, S., Atmaja, H., & Verawati, D. (2019). UMKM Sebagai Pilar Membangun Ekonomi Bangsa. *Jurnal REP (Riset Ekonomi Pembangunan)*, *4*(2), 1–189. https://doi.org/10.31002/rep.v4i2.1952.

SHI, X., CUI, Y., XU, W., ZHANG, J., & GUAN, Y. (2020). Formation permeability evaluation and productivity prediction based on mobility from pressure measurement while drilling. *Petroleum Exploration and Development*, *47*(1), 146–153. -https://doi.org/10.1016/S1876-3804(20)60013-1.

Silaban, D., Harahap, U. N., & Hasibuan, Y. M. (2025). Increasing Company Productivity by Using the Green Productivity Method at PT. Mitra Agung Sawita Sejati. *Jurnal Indonesia Sosial Teknologi*, *6*(1), 746–754. https://doi.org/10.59141/jist.-v6i1.8931.

Tian, J., & Liu, Y. (2021). Research on Total Factor Productivity Measurement and Influencing Factors of Digital Economy Enterprises. *Procedia Computer Science*, *187*(2019), 390–395. https://doi.org/10.1016/j.procs.2021.04.077.

Trubetskaya, A., McDermott, O., & McGovern, S. (2022). Implementation of an ISO 50001 energy management system using Lean Six Sigma in an Irish dairy: a case study. *TQM Journal*, *35*(9), 1–24. https://doi.org/10.1108/TQM-08-2022-0252.

Uddin, M. M. (2021). Improving Product Quality and Production Yield in Wood Flooring Manufacturing Using Basic Quality Tools. *International Journal for Quality Research*, *15* (1), 155–170. https://doi.org/10.24874/IJQR15.01-09.

Yudhanto, A. A., Rochima, E., & Rivani. (2023). Strategic Entrepreneurship and the Performance of Women-Owned Fish Processing Units in Cibinong District, Bogor Regency. *Economies*, *11*(3). https://doi.org/10.3390/economies11030088.