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Evaluation of Outages Based on the Saidi and Saifi Reliability Indices at PT. PLN (Persero) ULP Woha

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Abstract

The reliability of the electricity distribution system is a key factor determining the quality of service provided to customers. In medium-voltage networks, disturbances caused by external factors, particularly animal-related interference, remain a significant challenge that contributes to increased System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) values. This study aimed to evaluate the effectiveness of protective sleeve installation as a preventive measure for reducing feeder disturbances and improving distribution system reliability at PT PLN (Persero) ULP Woha. A quantitative descriptive approach was employed by analyzing and comparing disturbance data before and after protective sleeve installation during the 2024–2025 period. The findings revealed a significant reduction in the frequency and duration of disturbances following the installation of protective sleeves. Correspondingly, the improved SAIFI and SAIDI values indicated enhanced operational reliability of the distribution system. The results demonstrated that protective sleeves provided a practical and cost-effective solution for mitigating animal-related disturbances in medium-voltage distribution networks. The implications of this study include recommendations for PT PLN to adopt protective sleeves as a standard mitigation measure for animal-related disturbances across various customer service units and to support the development of more effective distribution network maintenance strategies.

INTRODUCTION

The electric power distribution system represents the final stage in electricity delivery to end users and plays a critical role in ensuring service continuity and quality (Abdelkader et al., 2024; Azmi et al., 2022; Gallegos et al., 2024; Ibrahim et al., 2024; Ten & Mehrizi-Sani, 2024). System reliability is commonly evaluated using standard indices, such as the System Average Interruption Frequency Index (SAIFI) and the System Average Interruption Duration Index (SAIDI), which measure the frequency and duration of customer interruptions, respectively. Within the operational area of PT PLN (Persero) ULP Woha, the 20 kV medium-voltage distribution network frequently experiences disturbances, with a significant proportion attributed to animal-related interference. Statistical records indicate that in 2024, there were 61 disturbance events, of which approximately 29.5% were caused by animals. This proportion increased to 33.8% of the 74 recorded incidents in 2025. These outages adversely affected system performance by increasing interruption frequency and duration, accelerating equipment degradation, and reducing customer satisfaction (Chen et al., 2022; Dowejko & Jaworski, 2025; Nazarychev & Tereshchenko, 2026; Udeh, 2024). Therefore, the implementation of effective preventive measures is essential. Among the available mitigation strategies, the installation of protective sleeves on exposed energized components has emerged as a promising approach (Agung et al., 2024; Irfandi et al., 2017).

Qualitatively, the reliability performance of the power distribution network at PLN UIW NTB indicates that distribution-side disturbances remain the primary contributors to outage frequency and duration. Although transmission-side disturbances occur less frequently, generator-related disturbances continue to contribute significantly to the overall interruption duration. Disturbance patterns fluctuate over time, with increasing trends during certain periods potentially influenced by external factors, such as weather conditions, system loading, or equipment conditions (Gonçalves et al., 2024; Nyangon, 2024; Patacca et al., 2023; Yadav et al., 2024). Furthermore, several feeders consistently appear as major contributors to disturbances, indicating the presence of critical points within the system that require prioritized maintenance and improvement efforts (Alshadood et al., 2023; Alvarez-Alvarado et al., 2022; Moradi-Sarvestani et al., 2024; Soares Ito et al., 2022; Thirumalai et al., 2024).

The novelty of this research lies in several aspects. First, this study specifically evaluates the effectiveness of protective sleeve installation on the Parado feeder at ULP Woha, which has unique animal-related disturbance characteristics involving birds, bats, geckos, and snakes. Second, this study applies a comparative approach by analyzing disturbance data from 2024 (before protective sleeve installation) and 2025 (after protective sleeve installation) on the same feeder. Third, this study integrates quantitative analysis of SAIDI and SAIFI indices with qualitative analysis based on field observations and interviews with technical personnel. Fourth, this study provides empirical evidence regarding the effectiveness and cost-efficiency of protective sleeve implementation as a mitigation strategy for animal-related disturbances. Fifth, this study contributes to the development of knowledge regarding best practices for improving distribution system reliability in Indonesia, particularly in areas with specific geographic and ecological characteristics.

This study aims to identify the dominant types and causes of feeder disturbances, evaluate the effectiveness of protective sleeve installation, and assess its impact on the reliability performance of the electricity distribution system (Bahri et al., 2025; PLN ICECRD, 2022).

METHOD

Types of Research

This research employed an applied research design with a descriptive-quantitative approach. The study aimed to analyze and evaluate the effectiveness of protective sleeve installation in reducing the frequency of feeder disturbances in medium-voltage networks and distribution substations at PT PLN (Persero) ULP Woha.

The quantitative approach was used to measure disturbance reduction based on numerical data, including the number of disturbances, disturbance duration, and reliability indices. Meanwhile, the descriptive approach was applied to describe the conditions of the distribution system and disturbance characteristics before and after protective sleeve installation.

Location, Object and Time of Research

Research Location:

PT PLN (Persero) ULP Woha which is located in Rabakodo, Woha District, Bima Regency, West Nusa Tenggara which is under the work area of the Bima Customer Service Implementation Unit (UP3), West Nusa Tenggara Regional Main Unit (UIW).

Figure 1. PT PLN (Persero) ULP Woha

Object of Research:

20 kV Medium Voltage Network and Distribution Substations that are experiencing disruptions in the work area of PT PLN (Persero) ULP Woha.

Research Time:

The research was carried out for ±7 months, starting from January-July 2025, including the stages of data collection, analysis, and the preparation of research report results.

Data and Data Sources

The data used in this study consists of two types, namely:

Primary Data

- The data from direct observation of the network location and distribution substations that are installed *protective sleeves*.
- The results of interviews with technical officers and network managers of PT PLN (Persero) ULP Woha related to the cause of the disturbance and its handling.
- Documentation of the physical condition of the tissue before and after the installation of the *protective sleeve*.

Secondary Data

- Historical data on feeder disturbances from the *Distribution Control Center* (DCC) system during the period 2024–2025.
- Data on the amount, type, and location of the outage.
- PLN's operational standards related to network maintenance and the installation of *protective sleeves* (e.g. SPLN and PUIL).
- Previous literature and research relevant to the topic of distribution disorders and *protective sleeves*.

Data Collection Methods

The methods used in data collection include:

Field Observation

It was carried out to see firsthand the condition of the network, distribution substations, and the installation of *protective sleeves* in the field, as well as to record potential locations prone to feed disturbances.

Interview

It was carried out to PLN employees in the distribution engineering section to get information about disturbance patterns, handling actions, and experience in the implementation of *protective* sleeves.

Documentation *Study*

Includes the collection of feeder disturbance data from PLN's operations and monitoring system (DCC) reports, as well as network technical data.

Research Variables

The variables used in this study are differentiated into:

Independent Variable (X):

Installation *of protective sleeves* on medium voltage networks and distribution substations.

Bound Variable (Y):

The level of animal feeder disturbance measured through:

1. Frequency of Interference *(SAIFI)*
2. Duration of Interruption *(SAIDI)*

Data Analysis Methods

Data analysis is carried out with the following steps:

Quantitative Analysis

Calculate *the value of SAIFI (System Average Interruption Frequency Index)* and *SAIDI (System Average Interruption Duration Index)* based on interference data before and after the installation of *the protective sleeve*.

Formula used (referring to IEEE Std 1366-2012):

$$SAIFI = \frac{\sum N_i}{N_t} \quad (1)$$

$$SAIDI = \frac{\sum (N_i \times T_i)}{N_T} \quad (2)$$

Where:

N_i = The number of customers affected by the ith disruption.

T_i = Duration of interruption i-i (hours).

T_i = Total customers served.

A comparison of *SAIFI* and *SAIDI* values before and after the installation of *the protective sleeve* will show how much of an impact it has on improving the reliability of the distribution system.

Qualitative Analysis

Explain the field conditions, the type of animals that cause the disturbance, the location of the vulnerability, and the effectiveness of the application *of protective sleeves* based on the results of observations and interviews.

Research Success Indicators

This research is considered successful if it meets the following criteria:

a. There was a decrease in the frequency of disturbance *(SAIFI)* and duration of disturbance *(SAIDI)* after the installation of the *protective sleeve*.
b. An increase in the reliability value of the distribution system in the feeder was observed.
c. There is field evidence that feeder interference is significantly reduced at the point where *the protective sleeve* is installed.

The following is a *flowchart* of the research implementation:

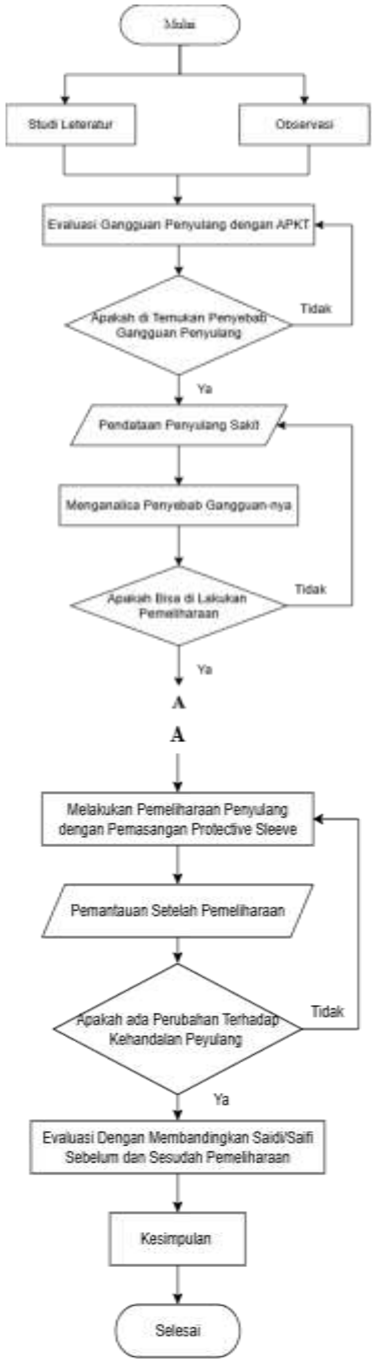

Figure 2. Research flowchart

RESULTS AND DISCUSSION

Monthly Monitoring of Supply Chain Disruptions

This dashboard displays monthly monitoring of feeder outages at PLN UIW NTB until March 30, 2026, with a total of 288 outages and the duration of outages reaching 130 hours 53 minutes 23 seconds. Disruptions were dominated by distribution with 204 incidents, followed by 70 incidents and transmission 14 incidents. The data also shows daily fluctuations in blackouts throughout the period from January 2024 to December 2025, as well as feeders with the highest contribution of disruptions such as Express Monta and Express GI-GH Bolo.

The following graph is based on the classification of disturbances that occurred during the period of 2024-2025, namely from January 2024 - December 2025.

Figure 3. Feeder Disruption Data

Monthly Monitoring Data for Feeder Disruptions Parado in 2024

The following graph is based on the classification of disturbances that occurred during the 2024 period.

Figure 4. Graph of total outages of parado feeder distribution disruption in 2024

Table 1. Duration of Feed Disruption Outage in 2024

Date	Feeder	Duration	Indications	Number of Customers
REC. BY	28-Mar-24	01.17.00	EF	2.284
REC. BY	12-Sep-24	00.04.00	EF	2.284
REC. BY	12-Sep-24	00.04.00	EF	2.284
OL. STOPPED	Dec 31, 2024	00.04.00	EF	12.274

Table 2. Causes of Feed Disturbance Outages

Yes	Date	Causes of Disorders
1	28-Mar-24	AR 1X, bird found on PD 002 location network
2	12-Sep-24	Found Bats stuck in the insulator
3	30-Nov-24	*Autoreclose* 2x then trip, geckos found in the network
4	Dec 31, 2024	Dead snake found on *Traves* location *of FCO Lere*

Based on the image above, the *calculation of SAIDI* and *SAIFI* is presented based on simulation of disturbances caused by animals in 2024 with a total of 2,284 customers.

March 2024 :

$$SAIDI = \frac{Number\ of\ Outages\ x\ Customer\ Outages}{Number\ of\ Customers} = \frac{1.17\ x\ 2.284}{2.284} = 1.17\ jam/Plg$$

$$SAIFI = \frac{Interference\ Outage\ x\ Customer\ Outage}{Number\ of\ Customers} = \frac{1\ x\ 2.284}{2.284} = 1\ kali/Plg$$

September 2024 :

$$SAIDI = \frac{Number\ of\ Outages\ x\ Customer\ Outages}{Number\ of\ Customers} = \frac{0.06\ x\ 2.284}{2.284} = 0.06\ jam/Plg$$

$$SAIFI = \frac{Interference\ Outage\ x\ Customer\ Outage}{Number\ of\ Customers} = \frac{1\ x\ 2.284}{2.284} = 1\ kali/Plg$$

November 2024 :

$$SAIDI = \frac{Number\ of\ Outages\ x\ Customer\ Outages}{Number\ of\ Customers} = \frac{0.5\ x\ 2.284}{2.284} = 0.5\ jam/Plg$$

$$SAIFI = \frac{Interference\ Outage\ x\ Customer\ Outage}{Number\ of\ Customers} = \frac{1\ x\ 2.284}{2.284} = 1\ kali/Plg$$

December 2024 :

$$SAIDI = \frac{Number\ of\ Outages\ x\ Customer\ Outages}{Number\ of\ Customers} = \frac{0.06\ x\ 12.274}{12.274} = 0.06\ jam/Plg$$

$$SAIFI = \frac{Interference\ Outage\ x\ Customer\ Outage}{Number\ of\ Customers} = \frac{1\ x\ 12.274}{12.274} = 1\ kali/Plg$$

Monthly Monitoring Data for Parado Feeder Disruptions in 2025

The following graph is based on the classification of disturbances that occurred during the 2025 period.

Figure 5. Graph of total outages of distribution disruptions in 2025

Table 3. Duration of Feeder Disturbance Outage in 2025

Date	Feeder	Duration	Indications	Number of Customers
REC. BY	18-Sep-25	00.50.33	EF	2.284

Table 4. Causes of Feed Disturbance Outages

No.	Date	Causes of Disorders
1	18-Sep-25	AR, Permanent Trip, found flash insulator fco dampela location

The following is presented the calculation of *SAIDI* and *SAIFI* based on simulation of disturbances due to natural factors in 2025 with the same number of customers.
September 2025 :

$$SAIDI = \frac{Number\ of\ Outages\ x\ Customer\ Outages}{Number\ of\ Customers} = \frac{0.83\ x\ 2.284}{2.284} = 0.83\ jam/Plg$$

$$SAIFI = \frac{Interference\ Outage\ x\ Customer\ Outage}{Number\ of\ Customers} = \frac{1\ x\ 2.284}{2.284} = 1\ kali/Plg$$

SAIDI-SAIFI Comparison Table for the Period of 2024-2025

The following is a comparison table *of SAIDI-SAIFI* before and after the installation of *protective sleeves*.

Table 5. Comparison of *SAIDI-SAIFI* for the Period of 2024-2025

No.	Moon	*SAIDI* 2024	*SAIDI* 2025
1	March	1.17 hours	-
2	September	0.06 hours	0.83 hours
3	November	0.5 hours	-
4	December	0.06 hours	-
5	March	1.17 hours	-

Table 6. Comparison of *SAIDI-SAIFI* for the Period of 2024-2025

No.	Moon	*SAIDI* 2024	*SAIDI* 2025
1	March	1 time	-
2	September	1 time	1 time
3	November	1 time	-
4	December	1 time	-
5	March	1 time	-

Based on the comparison table above, it shows that the value *of SAIDI* for the period 2025 has decreased the duration of disruption after the installation of protective *sleeves*. Meanwhile, the *SAIFI value* in the 2025 period also shows a decrease in the frequency of disturbances after the installation of *protective sleeves.*

SAIDI-SAIFI *Comparison Chart* for the Period of 2024-2025

Based on the results of the calculation *of SAIDI-SAIFI data* before and after the installation of *protective sleeves*.

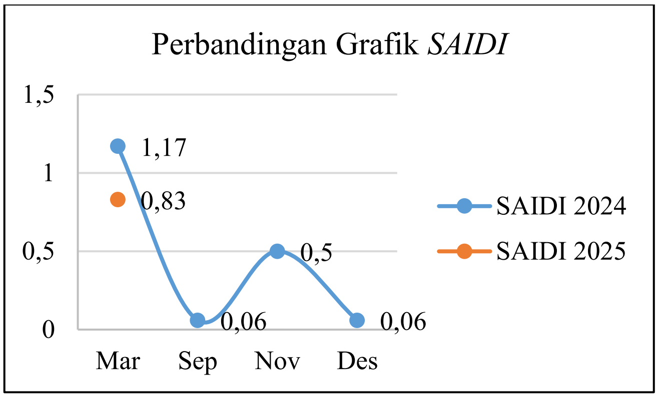

Figure 6. Comparison of *SAIDI* charts for the period of 2024-2025

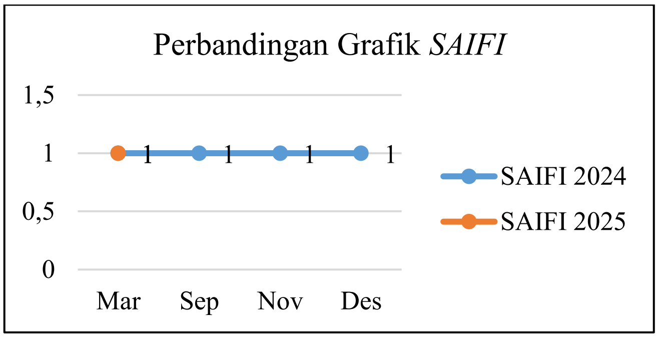

Figure 7. Comparison of *SAIFI* charts for the period 2024-2025

Based on the graph above, there is a significant decrease *in SAIDI-SAIFI*. Before the installation of *protective sleeves*, *SAIDI* in 2024 was recorded at 1.79 hours/customer/year, and *SAIFI* was recorded 4 times/customer/year. After the installation of the *protective sleeve*, *SAIDI* in 2025 was recorded at only 0.83 hours/customer/year and *SAIFI* decreased to only 1 time/customer/year.

CONCLUSION

Based on the analysis and discussion regarding the effectiveness of protective sleeve installation in reducing animal-related disturbances and improving distribution system reliability at PT PLN (Persero) ULP Woha, it can be concluded that protective sleeve installation was an effective solution for reducing the frequency and duration of disturbances on the Parado Feeder. This was demonstrated by the decrease in the SAIDI value from 1.79 hours/customer/year in 2024 (before installation) to 0.83 hours/customer/year in 2025 (after installation), as well as the reduction in the SAIFI value from 4 interruptions/customer/year to 1 interruption/customer/year. The SAIDI reduction reached 53.6%, while the SAIFI reduction reached 75%, indicating a significant improvement in distribution system reliability following protective sleeve installation. Protective sleeves proved to be an effective preventive mitigation measure for improving electricity service continuity, particularly in preventing animal-related disturbances caused by birds, bats, geckos, and snakes.

Based on these findings, several recommendations for future research can be proposed. First, further studies with longer observation periods (3–5 years) are needed to evaluate the long-term effectiveness of protective sleeves and identify potential material degradation. Second, research on optimizing protective sleeve placement based on animal types and regional characteristics is recommended to maximize mitigation effectiveness. Third, comprehensive cost-benefit analyses are needed to assess the economic value of protective sleeve implementation compared with potential losses caused by power interruptions. Fourth, future research could examine the integration of protective sleeves with other protection technologies, such as Internet of Things (IoT)-based monitoring systems and hotspot detection methods, to improve the overall effectiveness of disturbance mitigation. Fifth, comparative studies across regions with different animal disturbance characteristics could provide further insights into factors influencing protective sleeve effectiveness. Finally, the development of integrated standard operating procedures (SOPs) for protective sleeve installation and maintenance is necessary to ensure consistent implementation across various customer service units.

REFERENCES

Abdelkader, S., Amissah, J., & Abdel-Rahim, O. (2024). Virtual power plants: an in-depth analysis of their advancements and importance as crucial players in modern power systems. *Energy, Sustainability and Society*, *14*(1), 52.

Alshadood, D. M., Yaseen, A. Y., & Kshash, F. J. (2023). Priority Based Maintenance Management of Power Distribution Feeders using Critically Analysis and Condition Assessment. *University of Thi-Qar Journal for Engineering Sciences*, *13*(1), 81–88.

Alvarez-Alvarado, M. S., Donaldson, D. L., Recalde, A. A., Noriega, H. H., Khan, Z. A., Velasquez, W., & Rodriguez-Gallegos, C. D. (2022). Power system reliability and maintenance evolution: A critical review and future perspectives. *Ieee Access*, *10*, 51922–51950.

Azmi, K. H. M., Radzi, N. A. M., Azhar, N. A., Samidi, F. S., Zulkifli, I. T., & Zainal, A. M. (2022). Active electric distribution network: applications, challenges, and opportunities. *Ieee Access*, *10*, 134655–134689.

Bahri, H. J., Alawi, M. T., & Badri, F. (2025). Animal disturbance protection monitoring system at transformer substations. *Science Electro, 18*(1).

Chen, H., Yan, H., Gong, K., Geng, H., & Yuan, X.-C. (2022). Assessing the business interruption costs from power outages in China. *Energy Economics*, *105*, 105757.

Dowejko, J., & Jaworski, J. (2025). Beyond traditional grid: a novel quantitative framework for assessing automation's impact on system average interruption duration index and system average interruption frequency index. *Energies*, *18*(11), 2671.

Gallegos, J., Arévalo, P., Montaleza, C., & Jurado, F. (2024). Sustainable electrification—advances and challenges in electrical-distribution networks: a review. *Sustainability*, *16*(2), 698.

Gonçalves, A. C. R., Costoya, X., Nieto, R., & Liberato, M. L. R. (2024). Extreme weather events on energy systems: a comprehensive review on impacts, mitigation, and adaptation measures. *Sustainable Energy Research*, *11*(1), 4.

Ibrahim, A. H. M., Sadanandan, S. K., Ghaoud, T., Rajkumar, V. S., & Sharma, M. (2024). Incipient fault detection in power distribution networks: Review, analysis, challenges, and future directions. *IEEe Access*, *12*, 112822–112838.

Irfandi, R., Sirait, B., & Arsyad, M. I. (2017). Determination of the network reliability index of 20 kV distribution system at PT PLN (Persero) Singkawang Area with failure mode and effect analysis method. *Journal of Electrical Engineering, Energy, and Information Technology (J3EIT), 8*(2).

Moradi-Sarvestani, S., Dehbozorgi, M. R., & Rastegar, M. (2024). A three-stage reliability-centered framework for critical feeder identification, failure modes prioritization, and optimal maintenance strategy assignment in power distribution system. *Electric Power Systems Research*, *230*, 110215.

Nazarychev, A., & Tereshchenko, I. (2026). Power Quality Disturbances and Operating Regimes as Determinants of Reliability and Technical Condition of Industrial Electrical

Equipment: A Comprehensive Review. *Energies*, *19*(11), 2685.

Nyangon, J. (2024). Climate-proofing critical energy infrastructure: Smart grids, artificial intelligence, and machine learning for power system resilience against extreme weather events. *Journal of Infrastructure Systems*, *30*(1), 3124001.

Patacca, M., Lindner, M., Lucas-Borja, M. E., Cordonnier, T., Fidej, G., Gardiner, B., Hauf, Y., Jasinevičius, G., Labonne, S., & Linkevičius, E. (2023). Significant increase in natural disturbance impacts on European forests since 1950. *Global Change Biology*, *29*(5), 1359–1376.

PLN ICECRD. (2022). *Application of protective sleeve as an additional insulator in a 20 kV distribution system*.

Soares Ito, A., Ylipää, T., Gullander, P., Bokrantz, J., & Skoogh, A. (2022). Prioritisation of root cause analysis in production disturbance management. *International Journal of Quality & Reliability Management*, *39*(5), 1133–1150.

Ten, C.-W., & Mehrizi-Sani, A. (2024). *Electric Power Distribution Engineering*. CRC Press. https://doi.org/10.1201/9781003129721

Thirumalai, M., Hariharan, R., Yuvaraj, T., & Prabaharan, N. (2024). Optimizing distribution system resilience in extreme weather using prosumer-centric microgrids with integrated distributed energy resources and battery electric vehicles. *Sustainability*, *16*(6), 2379.

Udeh, E. (2024). Examining the impact of operation and production management failure on customer satisfaction and organizational growth: a qualitative study. *European Journal of Political Science Studies*, *7*(1).

Yadav, N. K., Patel, A. B., Singh, S. K., Mehta, N. K., Anand, V., Lal, J., Dekari, D., & Devi, N. C. (2024). Climate change effects on aquaculture production and its sustainable management through climate-resilient adaptation strategies: a review. *Environmental Science and Pollution Research*, *31*(22), 31731–31751.