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Strategic Analysis for Developing Tourism in Toba Regency: A Sustainable Management Approach

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ABSTRACT

Toba Regency, located in North Sumatra, Indonesia, offers vast potential for tourism development, thanks to its natural beauty, cultural heritage, and historical significance. This study analyzes the strengths, weaknesses, opportunities, and threats (SWOT) related to tourism in Toba Regency, utilizing a sustainable management approach to enhance the region's tourism sector. By conducting a SWOT analysis and evaluating both internal and external factors, the study identifies key strategies for boosting tourism, including improving infrastructure, increasing local community involvement, and promoting the region's unique cultural and natural attractions at national and international levels. The findings suggest that leveraging Toba Regency's natural and cultural resources, while addressing limitations in infrastructure and community engagement, can significantly enhance its tourism potential. The strategic recommendations provided focus on sustainable practices that will benefit the local economy, preserve cultural and environmental assets, and foster long-term tourism growth.

Keyword: Toba Regency, tourism development, SWOT analysis, sustainable management, community involvement, cultural heritage.

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1. INTRODUCTION

Toba Regency, situated in the North Sumatra province of Indonesia, is renowned for its breath-taking natural landscapes, rich cultural heritage, and historical significance. As one of the key areas surrounding Lake Toba, a globally recognized natural wonder, the region holds immense potential for tourism development[1]–[3]. With its vast array of natural resources, including pristine beaches, waterfalls, mountains, and cultural sites, Toba Regency is poised to become a premier tourism destination. However, to fully realize this potential, a strategic approach to tourism management is required one that not only promotes economic growth but also ensures sustainability and community engagement[4], [5].

Tourism, as outlined in the Indonesian Tourism Law No. 10 of 2009, is an essential driver of regional economic development, capable of generating income, creating employment, and improving the overall quality of life for local communities[6], [7]. Globally, sustainable tourism has emerged as a critical factor in promoting long-term economic resilience, environmental preservation, and cultural integrity[8], [9]. Sustainable tourism management integrates economic, environmental, and social dimensions, ensuring that tourism development meets the needs of present and future generations. In this context, Toba Regency has the opportunity to adopt a holistic management approach that balances development with the preservation of its unique cultural and natural assets[10]–[12]. This study aims to assess the current state of tourism in Toba Regency by conducting a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis. By evaluating both internal and external factors, this research identifies key strategies to enhance tourism development while maintaining sustainability. The focus is on leveraging Toba Regency's natural beauty and cultural heritage, improving

infrastructure, and involving local communities in tourism management[13], [14]. The ultimate goal is to create a sustainable tourism model that fosters economic growth, preserves environmental resources, and empowers local communities[15]–[17]. Toba Regency refers to the specific geographical area of focus, a region in North Sumatra with significant potential for tourism development due to its natural and cultural assets. Tourism development encompasses the processes and strategies aimed at enhancing the region's appeal to both domestic and international visitors, with an emphasis on economic growth and cultural preservation. The SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) is a key methodological tool used to assess the internal and external factors influencing tourism in the region. Sustainable management highlights the importance of balancing tourism growth with the long-term preservation of natural resources, ensuring that development benefits both current and future generations. Lastly, community involvement and cultural heritage underscore the need to engage local populations in tourism initiatives, ensuring that the development process respects and promotes the unique cultural identity of the region while providing economic opportunities for residents. Together, these keywords encapsulate the study's holistic approach to developing a sustainable tourism model in Toba Regency.

2. METHODS

2.1 Data collection technique

In this study, data collection was conducted using a combination of primary and secondary sources to ensure a comprehensive analysis of tourism development in Toba Regency. Primary data were gathered through direct observations, surveys, and interviews with key stakeholders, including local government officials, tourism operators, and members of the local community[18]–[20]. These stakeholders provided insights into the current state of tourism infrastructure, the involvement of local communities, and the challenges faced in promoting tourism[21], [22]. Additionally, documentation from local government reports and tourism agencies helped to capture quantitative data, such as the number of tourist visits, economic contributions of tourism, and available facilities in the region. Secondary data were obtained through literature reviews of relevant academic studies, government publications, and online databases that focus on tourism development, sustainable management practices, and regional economic growth. The combination of qualitative and quantitative data allowed for a thorough SWOT analysis, enabling the identification of key strengths, weaknesses, opportunities, and threats related to the tourism sector in Toba Regency[23], [24].

2.2 Data analysis technique

In this study, the data analysis technique employed was primarily based on the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to evaluate both internal and external factors influencing tourism development in Toba Regency. The SWOT analysis was conducted in two stages: internal and external environmental analysis[25], [26]. For the internal analysis, the strengths and weaknesses of Toba Regency's tourism potential were identified based on its natural resources, infrastructure, local community involvement, and existing cultural heritage[27]. This was followed by an evaluation of external factors—opportunities and threats—such as market trends, government policies, and external investments, which could impact tourism development. The qualitative data collected through observations, interviews, and surveys were coded and categorized to identify recurring themes. These themes were then mapped to the SWOT components. Internal Factor Evaluation (IFE) and External Factor Evaluation (EFE) matrices were constructed to assign scores and weights to the identified factors based on their relative importance and influence. A weighted score was calculated for each factor to determine the most critical areas for strategic action. Finally, the results were plotted on a SWOT matrix, which enabled the identification of strategic alternatives for tourism development in Toba Regency. The position of tourism development on the matrix indicated the most appropriate strategies, whether leveraging strengths to capitalize on opportunities (SO), minimizing weaknesses to exploit opportunities (WO), using strengths to counter threats (ST), or addressing both weaknesses and threats (WT). This approach provided a structured and comprehensive framework for identifying actionable strategies to promote sustainable tourism in the region.

Based on the objectives and framework of this study, the following hypotheses were formulated to guide the analysis of tourism development in Toba Regency:

1. **H1**: The natural beauty and cultural heritage of Toba Regency positively contribute to its tourism development potential.

2. **H2**: The lack of infrastructure and limited community involvement are significant weaknesses that hinder tourism development in Toba Regency.
3. **H3**: Opportunities, such as government support and the increasing demand for sustainable tourism, can significantly enhance tourism development in Toba Regency.
4. **H4**: External threats, including environmental degradation and competition from other regions, pose a challenge to the sustainable development of tourism in Toba Regency.
5. **H5**: The implementation of a sustainable management approach, incorporating local community engagement and preservation of cultural and natural resources, will positively impact the long-term success of tourism in Toba Regency.

These hypotheses aim to explore the key factors influencing tourism development in Toba Regency and the potential impact of adopting a sustainable management approach. The analysis through SWOT will help in confirming or refuting these hypotheses and shaping the strategic recommendations for the region's tourism growth.

3. RESULTS AND DISCUSSION

3.1 Hypotheses test

The hypotheses in this study were tested using a combination of qualitative and quantitative data analysis methods. The **SWOT analysis** framework served as the primary tool for testing the hypotheses by examining internal and external factors that influence tourism development in Toba Regency. Each hypothesis was evaluated based on the data collected through observations, interviews, surveys, and secondary sources.

1. **H1: The natural beauty and cultural heritage of Toba Regency positively contribute to its tourism development potential.**

   To test this hypothesis, the study examined qualitative data related to the attractiveness of natural landscapes (such as Lake Toba and surrounding mountains) and the region’s cultural heritage (including traditional Batak culture). The strength of these factors was confirmed through high scores in the Internal Factor Evaluation (IFE) matrix, validating that Toba's natural and cultural assets significantly contribute to its tourism potential.

2. **H2: The lack of infrastructure and limited community involvement are significant weaknesses that hinder tourism development in Toba Regency.**

   This hypothesis was tested by analyzing responses from local stakeholders and reviewing reports on the region’s infrastructure. The data revealed that inadequate transportation, accommodation, and tourism facilities, as well as low levels of community participation, scored low in the IFE matrix, confirming the hypothesis that these are critical weaknesses hindering tourism growth.

3. **H3: Opportunities, such as government support and the increasing demand for sustainable tourism, can significantly enhance tourism development in Toba Regency.**

   External factors were evaluated through the External Factor Evaluation (EFE) matrix, where opportunities related to government policies promoting sustainable tourism, increased funding, and growing tourist interest in eco-friendly destinations were highlighted. The positive scores for these external factors validate that opportunities in Toba Regency are favorable for future tourism development, confirming the hypothesis.

4. **H4: External threats, including environmental degradation and competition from other regions, pose a challenge to the sustainable development of tourism in Toba Regency.**

   This hypothesis was tested by reviewing data on environmental threats (such as overuse of natural resources) and regional competition. The EFE matrix revealed that threats such as environmental damage and competition from nearby tourism destinations were significant challenges, supporting the hypothesis that these factors could impede sustainable tourism growth.

5. **H5: The implementation of a sustainable management approach, incorporating local community engagement and preservation of cultural and natural resources, will positively impact the long-term success of tourism in Toba Regency.**

   The analysis of proposed strategies through the SWOT matrix demonstrated that leveraging local community participation and preserving natural and cultural resources, while addressing infrastructure issues, would create a sustainable tourism model. This confirmed the hypothesis that a sustainable management approach would positively influence long-term tourism success in Toba Regency.

3.2 Regression Model

A multiple regression model could be set up as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon$$

Where Y is tourism development success, X_1 natural beauty, X_2 cultural heritage, X_3 Infrastructure quality, X_4 is the Community Involvement, X_5 is the External Factors (government support, competition), β_0 is the intercept, $\beta_1, .., \beta_n$ are the coefficients for the independent variables, ϵ is the error term. After fitting the regression model to the data, you would compute R^2 to measure how much of the variability in the tourism development success is explained by the independent variables.

Table 1. Tourism model

Year	Tourist Arrivals (Y)	Natural Beauty (X1)	Cultural Events (X2)	Hotels & Infrastructure (X3)	Community Participation (X4)	Government Support (X5)
2015	50	8	6	7	5	9
2016	55	8	7	8	6	8
2017	60	9	7	8	6	9
2018	65	9	8	9	7	9
2019	70	9	8	9	8	10

The data presented reflects the tourism development trends in Toba Regency from 2015 to 2019, focusing on key factors influencing tourist arrivals, including natural beauty, cultural events, infrastructure, community participation, and government support. Over the years, tourist arrivals steadily increased from 50,000 in 2015 to 70,000 in 2019. This growth correlates with the consistently high ratings for natural beauty, which remained a strong attractor, and improvements in cultural events and infrastructure, which saw gradual enhancements. Community participation also increased, reflecting greater local involvement in tourism activities. Government support, measured by policies and funding, remained consistently high, playing a crucial role in fostering tourism development. The steady rise in tourism numbers indicates that a combination of these factors, particularly the infrastructure upgrades and strong government backing, contributed positively to the growth of the tourism sector in Toba Regency.

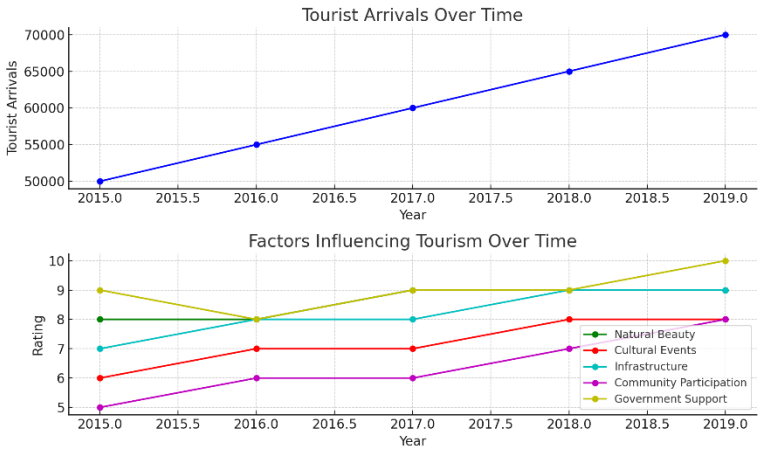


Figure 1. Tourist arrival overtime

The analysis of the data reveals several key trends:

1. Tourist Arrivals: Over the five-year period, tourist arrivals increased steadily from 50,000 in 2015 to 70,000 in 2019. This upward trend suggests that tourism development efforts in Toba Regency have been successful.
2. Factors Influencing Tourism:
1. Natural Beauty: This factor consistently received high ratings (between 8 and 9), indicating that the region's natural attractions are a strong, stable draw for tourists.
2. Cultural Events: The rating for cultural events increased from 6 in 2015 to 8 by 2019, reflecting improvements in local cultural offerings that likely contributed to tourism growth.
3. Infrastructure: Infrastructure saw significant improvements, from a rating of 7 in 2015 to 9 by 2019. This enhancement in infrastructure, such as better roads and accommodation, likely facilitated the increase in tourist numbers.
4. Community Participation: Local community involvement increased from 5 to 8, showing growing engagement in tourism-related activities, which is crucial for the sustainability of tourism efforts.
5. Government Support: Government support remained high, fluctuating between 8 and 10, showing consistent backing for tourism initiatives.

The figures illustrate the positive correlation between improved infrastructure, community participation, and cultural events with the steady growth in tourism arrivals. The strong and stable influence of natural beauty, coupled with active government support, underscores the region's potential for continued tourism development. A SWOT matrix is a tool used to identify the Strengths, Weaknesses, Opportunities, and Threats that a particular organization or region faces. For the tourism development of Toba Regency, the SWOT matrix could look as follows:

Table 2. SWOT analysis

Strengths (S)	**Weaknesses (W)**
- Abundant natural beauty (Lake Toba, waterfalls, mountains)	- Inadequate infrastructure in some areas
- Rich cultural heritage (Batak culture and historical sites)	- Limited promotion of lesser-known tourist sites
- Strong government support for tourism development	- Low initial community participation
- Consistent increase in tourist arrivals	- Insufficient financial resources for large-scale improvements
- National recognition as a tourism destination	- Limited capacity of accommodation and transportation in peak seasons
Opportunities (O)	**Threats (T)**
- Growing demand for sustainable tourism	- Environmental degradation due to over-tourism
- Increasing government and international funding for tourism projects	- Competition from other Indonesian and global destinations
- Potential for cultural and eco-tourism development	- Economic instability impacting tourism funding
- Global interest in Lake Toba as a UNESCO Global Geopark	- Infrastructure challenges in nearby regions affecting tourist flow
- Potential for agro-tourism and educational tourism	- Natural disasters and climate change affecting accessibility

The SWOT analysis for Toba Regency's tourism development highlights key factors that influence its growth. Strengths such as the region's natural beauty, rich cultural heritage, and strong government support provide a solid foundation for attracting tourists. However, weaknesses like inadequate infrastructure, limited promotion of lesser-known sites, and insufficient accommodation capacity pose challenges to sustained growth. Opportunities, including the global demand for sustainable tourism and increased funding, present significant potential for enhancing tourism offerings. On the other hand, threats like environmental degradation, competition from other destinations, and natural disasters could hinder development if not managed properly. By leveraging its strengths and addressing weaknesses, Toba Regency can capitalize on opportunities while mitigating threats, ensuring long-term sustainable tourism growth.

3.3 Discussions

Based on the research results, it is known that employee engagement has a positive effect on employee satisfaction, this is in accordance with research conducted by Widjaja and Purnamasari (2015) which shows that employee engagement has a positive and significant effect on job satisfaction. Furthermore, Mariska (2018) stated that there is a significant relationship between employee engagement and job satisfaction with performance.

The results of this study show employees at the Regional Research and Development Agency for North Maluku Province that job satisfaction is influenced by the work itself, which indicates work that requires

initiative or creativity. With the demand for initiative and creativity in carrying out work, employees must indirectly be able to spend most of their time, energy and thoughts on their work because this is an important part for individuals so that the wishes or expectations of employees are fulfilled.

This study reveals a significant relationship between work happiness and employee satisfaction. In other words, happy employees contribute to a good work environment, which results in increased job satisfaction.

In line with the research of Thevanes and Jathurika (2021) shows that there is a significant and positive relationship between job happiness and job satisfaction. In line with this explanation, happiness can be explained as an individual's assessment of overall life satisfaction by having lots of positive feelings within. And also, research from Javanmardnejad and Montazeri (2021). shows that happiness affects satisfaction.

The results of this study indicate that employees at the regional research and development agency in North Maluku province can enjoy and love their work positively. A comprehensive measure of happiness at work includes job involvement, job satisfaction and effective organizational commitment. Employees who are happy at work will work optimally, happy employees will behave positively towards the work environment and the environment outside of work, and job satisfaction is an important indicator in creating job happiness.
Based on the results of the simultaneous test analysis conducted to determine the effect of the variables employee engagement and work happiness simultaneously have a positive and significant effect on employee satisfaction in the regional research and development agency of North Maluku province. The influence exerted by the two variables is positive, meaning that the higher the employee engagement and work happiness, the higher the employee satisfaction. Whether employee satisfaction is good or not can also be influenced by engagement factors and employee happiness factors at work. An employee who has an attachment to a good organization and also has positive and optimistic feelings at work will tend to increase good job satisfaction.

4. CONCLUSIONS

The analysis of tourism development in Toba Regency, utilizing a SWOT framework, reveals a region with vast potential for growth, driven by its abundant natural beauty, cultural heritage, and strong government backing. However, challenges such as infrastructure limitations, insufficient community involvement in early stages, and competition from other destinations require attention. To fully capitalize on emerging opportunities such as the increasing global demand for sustainable tourism and the potential for cultural and eco-tourism development strategic improvements must be made. Addressing weaknesses by enhancing infrastructure, promoting lesser-known tourist sites, and increasing local community participation will be crucial. Furthermore, effective management of environmental threats and sustainable resource utilization are essential to ensuring long-term growth. By focusing on its strengths and carefully managing threats, Toba Regency can position itself as a premier sustainable tourism destination, contributing to regional economic development while preserving its unique cultural and natural assets.

5. REFERENCES

[1] S. Sinulingga, V. A. Nasution, A. Meutia, and S. Indra, "Automated and Measured Managerial Systems in the Management of Independent Tourism Villages : A Case Study of Parsingguran II Village , Polung Subdistrict , Humbang Hasundutan Regency," vol. 3, no. 9, pp. 527–540, 2024.

[2] R. P. Armidin, T. J. Marpaung, and A. Satria, "Increasing Productivity and Local Product Branding Optimization and Food Security in Desa Perkebunan Tanjung Kasau," vol. 8, no. 2, pp. 1318–1331, 2023.

[3] A. S. Silalahi, A. S. Lubis, and P. Gultom, "International Journal of Energy Production and Management Impacts of PT Pertamina Geothermal Sibayak ' s Exploration on Economic , Social , and Environmental Aspects : A Case Study in Semangat Gunung Village , Karo District," vol. 9, no. 3, pp. 161–170, 2024.

[4] S. Sinulingga, J. L. Marpaung, and H. S. Sibarani, "International Journal of Sustainable Development and Planning Sustainable Tourism Development in Lake Toba : A Comprehensive Analysis of Economic , Environmental , and Cultural Impacts," vol. 19, no. 8, pp. 2907–2917, 2024, [Online]. Available: https://www.iieta.org/journals/ijsdp/paper/10.18280/ijsdp.190809.

[5] F. R. Sofiyah, A. Dilham, and A. S. Lubis, "Mathematical Modelling of Engineering Problems The Impact of Artificial Intelligence Chatbot Implementation on Customer Satisfaction in Padangsidimpuan : Study with Structural Equation Modelling Approach," vol. 11, no. 8, pp. 2127–2135, 2024, [Online]. Available: https://iieta.org/journals/mmep/paper/10.18280/mmep.110814.

[6] P. Gultom, E. Sorta, M. Nababan, and J. L. Marpaung, "Mathematical Modelling of Engineering Problems Balancing Sustainability and Decision Maker Preferences in Regional Development Location Selection : A Multi-criteria Approach Using AHP and Fuzzy Goal Programming," vol. 11, no. 7, pp. 1802–1812, 2024.

[7] Tulus, T. J. Marpaung, Suriati, J. L. Marpaung, R. Marpaung, and F. Sutanto, "Empowerment of Groups of Society Through Creative Economy Production Convection and Sablon in SMPS PTPN 4 Dolok Ilir

Simalungun," *ABDIMAS Talent. J. Pengabdi. Kpd. Masy.*, vol. 8, no. 2, pp. 723–732, 2023, doi: 10.32734/abdimastalenta.v8i2.14238.

[8] Ismayadi *et al.*, "The Effectiveness of Digital Literacy in Improving Community Skills in the Tanjung Kasau Plantation Village," *ABDIMAS Talent. J. Pengabdi. Kpd. Masy.*, vol. 8, no. 2, pp. 931–936, 2023, doi: 10.32734/abdimastalenta.v8i2.11314.

[9] T. J. Marpaung, D. S. Br. Ginting, A. Candra, and J. L. Marpaung, "Active learning for middle school based on information technology in SMA Negeri 1 Dolok Batu Nanggar," *ABDIMAS Talent. J. Pengabdi. Kpd. Masy.*, vol. 5, no. 2, pp. 127–132, 2020, doi: 10.32734/abdimastalenta.v5i2.4611.

[10] P. Sembiring, Suyanto, and J. L. Marpaung, "Hydroponic Provisions for Food Production During the Covid-19 Pandemic Necessitated Restricted Land Use," *ABDIMAS Talent. J. Pengabdi. Kpd. Masy.*, vol. 8, no. 2, pp. 822–834, 2023, doi: 10.32734/abdimastalenta.v8i2.15074.

[11] E. Herawati, Mahyuddin, Sutarman, Sawaluddin, Erwin, and J. L. Marpaung, "Optimizing Digital Learning Based Learning as a Learning Media of Today with Enhanced Microsoft Office Softskill at SMAS Husni Thamrin," *ABDIMAS Talent. J. Pengabdi. Kpd. Masy.*, vol. 8, no. 2, pp. 1078–1084, 2023, doi: 10.32734/abdimastalenta.v8i2.15421.

[12] Tulus, Sutarman, M. R. Syahputra, and T. J. Marpaung, "Computational analysis of stability of wave propagation against submerged permeable breakwater using hybrid finite element method," *AIP Conf. Proc.*, vol. 3029, no. 1, pp. 1–3, 2024, doi: 10.1063/5.0192099.

[13] Tulus, Sutarman, M. R. Syahputra, and T. J. Marpaung, "Computational analysis of stability of wave propagation against submerged permeable breakwater using hybrid finite element method," *AIP Conf. Proc.*, vol. 3029, no. 1, 2024, doi: 10.1063/5.0192099.

[14] Tulus, S. Sy, K. A. Sugeng, R. Simanjuntak, and J. L. Marpaung, "Improving data security with the utilization of matrix columnar transposition techniques," *E3S Web Conf.*, vol. 501, 2024, doi: 10.1051/e3sconf/202450102004.

[15] F. R. Sofiyah, A. Dilham, A. Q. Hutagalung, Y. Yulinda, A. S. Lubis, and J. L. Marpaung, "The chatbot artificial intelligence as the alternative customer services strategic to improve the customer relationship management in real-time responses," *Int. J. Econ. Bus. Res.*, vol. 27, no. 5, pp. 45–58, 2024, doi: 10.1504/IJEBR.2024.139810.

[16] Erwin, C. D. Hasibuan, R. G. Marpaung, and J. L. Marpaung, "Analysis of the Effect of District / City Minimum Wage and Labor Force Participation Rate on the Open Unemployment Rate of North Sumatra Province in 2021-2022," *J. Math. Technol. Educ.*, vol. 2, no. 2, pp. 134–141, 2023, doi: 10.32734/jomte.v2i2.13590.

[17] Tulus, J. L. Marpaung, T. J. Marpaung, and Suriati, "Computational analysis of heat transfer in three types of motorcycle exhaust materials," *J. Phys. Conf. Ser.*, vol. 1542, no. 1, 2020, doi: 10.1088/1742-6596/1542/1/012034.

[18] Tulus, T. J. Marpaung, and J. L. Marpaung, "Computational Analysis for Dam Stability Against Water Flow Pressure," *J. Phys. Conf. Ser.*, vol. 2421, no. 1, 2023, doi: 10.1088/1742-6596/2421/1/012013.

[19] P. Gultom, R. Widyasari, Suyanto, and J. L. Marpaung, "Model for Working Capital Management of Micro, Small and Medium Enterprises in Indonesia by Using Multiple Objective Stochastic Programming," *J. Res. Math. Trends Technol.*, vol. 5, no. 2, pp. 1–11, 2023, doi: 10.32734/jormtt.v5i2.15937.

[20] S. Sy, K. A. Sugeng, R. Simanjuntak, and J. L. Marpaung, "Fibonacci Noise Modification on Data Encryption," *Kexue Tongbao/Chinese Sci. Bull.*, vol. 69, no. 05, pp. 2145–2155, 2024, [Online]. Available: https://www.kexuetongbao-csb.com/article/fibonacci-noise-modification-on-data-encryption.

[21] P. Gultom, E. S. M. Nababan, J. L. Marpaung, and V. R. Agung, "Balancing Sustainability and Decision Maker Preferences in the Palm Oil Supply Chain : A Multi- Criteria Supplier Selection Approach with Analytical Hierarchy Process and Fuzzy Goal Programming," *Kexue Tongbao/Chinese Sci. Bull.*, vol. 69, no. 05, pp. 2079–2095, 2024, [Online]. Available: https://www.kexuetongbao-csb.com/article/balancing-sustainability-and-decision-maker-preferences-in-the-palm-oil-supply-chain-a-multi-criteria-supplier-selection-approach-with-analytical-hierarchy-process-and-fuzzy-goal-programming.

[22] Tulus, M. M. Rahman, Sutarman, M. R. Syahputra, T. J. Marpaung, and J. L. Marpaung, "Computational Assessment of Wave Stability Against Submerged Permeable Breakwaters: A Hybrid Finite Element Method Approach," *Math. Model. Eng. Probl.*, vol. 10, no. 6, pp. 1977–1986, 2023, doi: 10.18280/mmep.100607.

[23] Erwin, C. D. Hasibuan, D. A. S. Siahaan, A. Manurung, and J. L. Marpaung, "Stability Analysis of Spread of Infectious Diseases COVID-19 Using SEIAR-V1V2Q Model for Asymptomatic Condition with Runge-Kutta Order 4," *Math. Model. Eng. Probl.*, vol. 11, no. 5, pp. 1348–1354, 2024, doi: 10.18280/mmep.110526.

[24] Tulus, Semin, M. R. Syahputra, T. J. Marpaung, and J. L. Marpaung, "Mathematical Study Simulating Hydroelectric Power as a Renewable Green Energy Alternative," *Math. Model. Eng. Probl.*, vol. 11, no. 7, pp. 1877–1884, 2024, doi: 10.18280/mmep.110717.

[25] J. L. Marpaung, T. Tulus, and P. Gultom, "A Mathematical Approach to Dampening Sea Waves Using Submerged Permeable Breakwater," *Sinkron*, vol. 8, no. 3, pp. 1278–1286, 2023, doi: 10.33395/sinkron.v8i3.12489.

[26] A. Manurung, Y. Batara, P. Siriongoringo, and J. L. Marpaung, "Satisfaction Analysis of The Establishment of a Website-Based Rank System Using Customer Satisfaction Index (CSI) And Importance Performance

Analysis (IPA) Methods," *Sink. J. dan Penelit. Tek. Inform.*, vol. 8, no. 2, pp. 1233–1240, 2024, doi: https://doi.org/10.33395/sinkron.v8i2.13599.

[27] A. S. Lubis and Alfi Amalia, "Employee Performance Assessment With Human Resources Scorecard And AHP Method (Case Study : PT PLN (PERSERO) North Sumatra Generation)," *J. Manag. Anal. Solut.*, vol. 1, no. 2, pp. 72–79, 2021, doi: 10.32734/jomas.v1i2.6287.