JOWRM

Journal of Water Resources Management

Journal homepage: https://journal.water.gov.my

e-ISSN: 2811-3578

Local Community Perspectives on the Implications of E-Fence as a Nature-Based Coastal Protection Strategy in Malaysia

Muhammad Fauzi Rodzee[1,a], Effi Helmy Ariffin[1,b*]

[1]Institute of Oceanography and Environment,
Universiti Malaysia Terengganu, Kuala Nerus, 21030, MALAYSIA

*effihelmy@umt.edu.my

Email: [a]s65572@ocean.umt.edu.my, [b]effihelmy@umt.edu.my

Received 09 Mac 2026;
Accepted 29 Jun 2026;
Available online 30 Jun 2026

Abstract: Coastal erosion is a growing challenge, especially on the East Coast of Peninsular Malaysia, threatening both the environment and the community. Numerous coastal structures have been implemented in the last decade; however, only a few studies have examined their livelihood implications. Therefore, this study evaluates the role of E-Fence as a sustainable coastal erosion mitigation measure and explores preliminary community perspectives on its socioeconomic benefits. Field observations were performed to compare beach profiles with and without E-Fence structures using theodolite and total station surveying. In addition, semi-structured interviews were conducted to capture the community's perspective on the E-Fence. Analysis using the Profiler 3.2 XL program indicates dune restoration in the transect protected by the structures. Meanwhile, the survey revealed predominantly positive feedback, indicating strong community acceptance of the eco-engineering approach to beach stabilization. Overall, E-Fence emerges as an effective nature-based coastal structure that enhances beach stabilization and provides indirect livelihood benefits by protecting economic activities, including restaurants and small-scale fisheries.

Keywords: Eco-engineering, Coastal erosion, Beach profile, Livelihood resilience, Terengganu

1. Introduction

In the past century, coastal erosion has been a growing global-scale pressure threatening coastal communities (Angnuureng et al., 2025). The scenario is defined as the landward retreat of shorelines, including their dynamic reconfiguration due to natural and anthropogenic factors. Climate change is the leading natural cause of Sea-Level Rise (SLR) and intensified storm events as it alters the fundamental balance of coastal morphology (Dong et al., 2024). Meanwhile, anthropogenic influences along the coastline are often associated with the implementation of coastal hard structures, which may be constructed for protection or other coastal management purposes (Zulfakar et al., 2021).

A previous study by Ariffin et al. (2018) showed that the airport tarmac extension in Kuala Terengganu significantly affected local hydrodynamic behavior, including erosion in the northern areas. As a result, several hard structures such as revetments and groynes were installed along the coastline to mitigate the problem. However, such structures often intensify erosion in adjacent areas by interrupting the natural sediment supply transported by longshore drift (Joe et al., 2025; Rashidi et al., 2021). This is where the idea of a potential Nature-based Solution (NbS) to control erosion naturally, without altering the longshore sediment transport mechanism.

E-Fence (Effective Fence) structures were first introduced at Pantai Batu Rakit, Kuala Nerus, Terengganu. It is considered an alternative to a conventional structure for mitigating coastal erosion. E-Fence works with nature by trapping sediment and promoting dune growth (Zainuddin et al., 2024). Although its effectiveness was proven for beach stabilization, its broader socioeconomic implications for coastal communities remain underexplored. Therefore, this paper is to evaluate the role of E-Fence as a nature-based coastal protection structure and explore its socio-economic impacts on coastal communities in Kuala Nerus, Terengganu.

2. Research Methods and Materials

2.1 Description of the Study Area

Terengganu is located on the East Coast of Peninsular Malaysia, facing the South China Sea at 315° (Ariffin et al., 2018). The region is controlled by the Northeast Monsoon (NEM) and the Southwest Monsoon (SWM), which occur from November to March and May to September, respectively. The NEM produces strong onshore winds and high-energy waves of 1 – 2 m, which frequently accelerate coastal erosion and flooding, whereas wave heights during the SWM usually remain below 0.8 m (Bagheri et al., 2019; Ariffin et al., 2018).

This study focuses on Pantai Sauh (5.4573° N, 103.0407° E) with reference to Pantai Batu Rakit (5.4516° N, 103.0469° E), two natural sandy beaches located in the Kuala Nerus

**Corresponding author: effihelmy@umt.edu.my*
2026 JPS Publishing. All right reserved.

district (Fig. 1) that are predominantly shaped by sediment inputs from the Terengganu River (Raj, 1982). Both areas support local fisheries, tourism, and maritime activities and serve as important public spaces for recreation and educational purposes (Ismail et al., 2025; Ariffin et al., 2018).

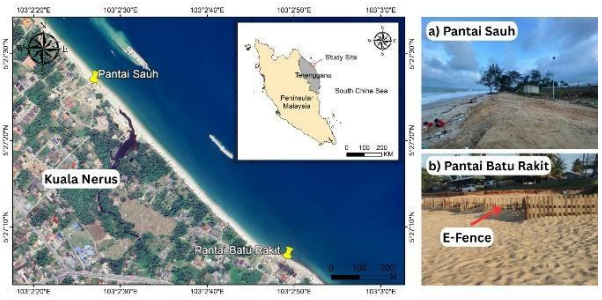

Fig. 1 – Map of the study area.

2.2 Methodology

2.2.1 Research Design

This study employed a mixed-method research design that combines quantitative and qualitative approaches. The quantitative technique was used to investigate physical changes in the coastal environment through field measurements and data analysis, whilst a qualitative approach was employed to record community perceptions of the construction of E-Fence structures. The combination of these methodologies allows for a more comprehensive understanding of both the physical performance of the coastal intervention and its consequences for the surrounding population.

2.2.2 Data Collection

In situ beach profile measurements were carried out at Pantai Batu Rakit using a theodolite and total station. Transects T1 and T7 were selected to allow a direct comparison of shoreline conditions in the absence and presence of the structures. T1 was in the adjacent unprotected area, while T7 was positioned within the E-Fence zone where sediment trapping and dune recovery were observed. The distance between both transects was approximately 18 m, with each transect spaced at 3 m intervals. Elevation data were collected during low tide to minimize tidal influence and were processed using Profiler 3.2 XL software to generate beach profiles and assess changes in beach morphology, including beach slope and dune formation. The profile comparisons were then used to evaluate the effectiveness of the E-Fence in trapping sediment and improving beach stability.

A preliminary semi-structured interview survey involving three respondents (n = 3, with respondents selected to represent villages in Batu Rakit including Kampung Tanjung and Kampung Pengkalan Atap) was conducted to obtain early community perspectives on coastal erosion, the effectiveness of the structures, and its influence on local livelihood activities. The survey questions are as follows.

- Were you aware of the E-Fence structures that had been installed along Pantai Batu Rakit?
- How would you describe the coastal erosion conditions before the E-Fence was installed, particularly in terms of shoreline retreat and its impacts on the surrounding community?
- What changes have you observed after the installation of the E-Fence, especially regarding beach width and elevation?
- Since the implementation of the E-Fence, how has the coastal area changed in terms of daily activities, tourism, and environmental conditions?

3. Results and Discussions

3.1 Beach Profile Survey

Field observations indicate clear differences between protected and unprotected transects. The area behind the E-Fence indicates sediment accretion, suggesting that the structure acts as a barrier that reduces wind and wave energy, thereby promoting sediment deposition at the backshore (Zainuddin et al., 2024). Over time, this process facilitates dune formation and contributes to a more stable beach profile (Fig. 2). In contrast, the unprotected section exhibits a steeper beach profile, where sediments are more readily transported seaward due to the absence of structures that can attenuate wave and wind forces.

The present study mainly represents short-term observations conducted after the installation of the E-Fence structures. Although sediment accumulation and dune recovery were clearly observed, long-term monitoring covering both the Northeast Monsoon (NEM) and Southwest Monsoon (SWM) seasons is still ongoing to further assess the stability and performance of the structures under different coastal conditions.

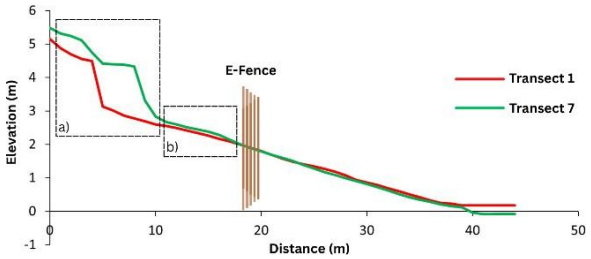

Fig. 2 – Comparison of the beach profiles morphology at Pantai Batu Rakit. a) Beach slope. b) Dune formation.

Field observations and volumetric analysis showed noticeable differences between the unprotected transect (T1) and the E-Fence protected transect (T7). The protected section recorded consistently higher sediment volumes, reflecting greater sediment accumulation and better beach stability. The significant changes were observed within the 0 – 10 m section, which represents the beach slope area, where sediment volume increased between 10.2% and 46.6%, with the highest increase recorded between 6 – 8 m. Beyond this zone, smaller but steady increases from 10 – 17 m indicated gradual dune development behind the E-Fence structures. These results suggest that the E-Fence helps slow down wind and wave energy, allowing more sediment to settle and supporting dune recovery compared to the nearby unprotected section.

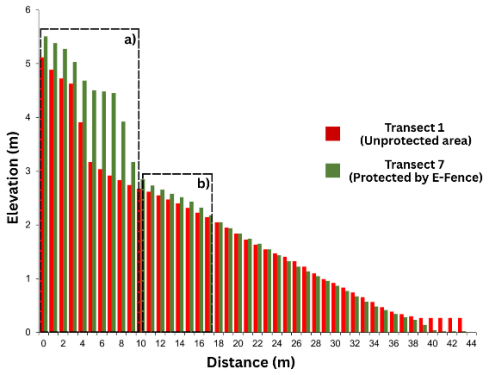

Fig. 3 – Comparison of the beach volume changes at Pantai Batu Rakit. a) Beach slope. b) Dune formation.

Table 1 – Summary of the beach volume changes calculation.

Distance (m)	T1 Section Volume (m^3)	T7 Section Volume (m^3)	Volume Changes (m^3/m)	Percentage Change (%)
0 – 2	14.7	16.2	1.5	10.2
2 – 4	13.3	15.0	1.7	12.8
4 – 6	10.1	13.7	3.6	35.6
6 – 8	8.8	12.9	4.1	46.6
8 – 10	8.3	9.9	1.6	19.3
10 – 12	7.8	8.2	0.4	5.1
12 – 14	7.4	7.8	0.4	5.4
14 – 16	6.9	7.3	0.4	5.8
16 – 17	4.4	4.5	0.1	2.3

3.2 Community Perspective on E-Fence Structures

The E-Fence structures at Pantai Batu Rakit have received positive feedback from the community (Table 2). They were aware of the comparison between the protected and unprotected areas. Nature-based coastal preservation measures have positively influenced community activities and local livelihoods, particularly benefiting fishing and small-scale businesses.

Table 2 – Evaluation of the community feedback before and after the E-Fence implementation.

Theme	Participant Response (P)	Explanation
Awareness of E-Fence installation	These sand fences were installed in 2022. (P1) Around two years ago. (P2) In 2018. (P3)	Participants were generally aware of the E-Fence installations along Pantai Batu Rakit, although their opinions varied slightly. This suggests a moderate level of community awareness about coastal protection initiatives.
Coastal conditions before installation	The beach width narrowed due to erosion. (P1) Coastal erosion can cause the beach slope to become steeper. (P3)	Before the E-Fence installation, respondents reported significant coastal erosion, including reduced beach width and steeper beach profiles, which affect the coastline's stability.
Changes after E-Fence installation	Dune accretion increased beach width and volume. (P1) Trapped sand contributes to rebuilding dunes. (P2) Sand fences help stabilize the beach slope by trapping sediment. (P3)	After installation, they reported significant changes, including sediment accumulation, broader beaches, and progressive dune rebuilding, demonstrating the importance of E-Fence structures in supporting coastal stabilization.
Community and livelihood impacts	Restored dunes enhance the aesthetic appeal and attract visitors. (P1) Dunes act as natural barriers that reduce erosion. (P2) Regular monitoring and maintenance are necessary. (P3)	The findings suggest that improved coastal conditions may help support different livelihood activities within the local community, including fishing and small-scale coastal businesses. However, because the number of respondents was limited, these observations should be considered preliminary and not treated as conclusive gender-based findings.

4. Conclusion

In conclusion, this study shows that E-Fence structures have strong potential as a nature-based approach for mitigating coastal erosion through sediment trapping and dune restoration. Field observations at Pantai Batu Rakit showed that the protected area generally developed wider and more stable beach profiles compared to the unprotected section, indicating the effectiveness of the structures in supporting shoreline stability.

Community feedback also showed positive views toward the environmental and livelihood benefits associated with the E-Fence implementation. The improved coastal environment at Pantai Batu Rakit benefits small-scale businesses, including seaside restaurants owned and managed by women (Fig. 4). Meanwhile, observations and references to Pantai Sauh indicate that E-Fence deployment could benefit male-dominated fishing operations by stabilizing the beach and establishing a safer location for boat parking and coastline access (Fig. 5). However, due to the limited number of respondents, the social findings should be interpreted as an indicative community perspective rather than statistically representative community opinions. Future studies should

include longer monitoring periods across different monsoon seasons, larger-scale community assessments, and additional beach transects within and adjacent to the E-Fence areas to provide a more representative comparison of protected and unprotected coastal environments.



Fig. 4 – Seaside restaurants near Pantai Batu Rakit also benefit from the E-Fence structures, which help to control coastal erosion by encouraging dune growth.



Fig. 5 – E-Fence implementation at Pantai Sauh, highlighting potential benefits to fishermen from future beach stabilization.

Acknowledgement

The authors would also like to acknowledge the editors and an anonymous reviewer, who contributed immensely to improving the quality of this publication. This work was supported by the Ministry of Higher Education (MOHE) of Malaysia under the Fundamental Research Grant Scheme (FRGS) FRGS/1/2022/WAB02/UMT/02/1.

References

[1] Angnuureng, D. B., Charuka, B., Almar, R., Dada, O. A., Asumadu, R., Agboli, N. A., & Ofosu, G. T. (2025). Challenges and lessons learned from global coastal erosion protection strategies. IScience, 28(4). https://doi.org/10.1016/j.isci.2025.112055

[2] Ariffin, E. H., Sedrati, M., Akhir, M. F., Daud, N. R., Yaacob, R., & Husain, M. L. (2018). Beach morphodynamics and evolution of monsoon-dominated coasts in Kuala Terengganu, Malaysia: Perspectives for integrated management. Ocean and Coastal Management, 163, 498–514. https://doi.org/10.1016/j.ocecoaman.2018.07.013

[3] Bagheri, M., Zaiton Ibrahim, Z., bin Mansor, S., Abd Manaf, L., Badarulzaman, N., & Vaghefi, N. (2019). Shoreline change analysis and erosion prediction using historical data of Kuala Terengganu, Malaysia. Environmental Earth Sciences, 78(15). https://doi.org/10.1007/s12665-019-8459-x

[4] Dong, W. S., Ismailluddin, A., Yun, L. S., Ariffin, E. H., Saengsupavanich, C., Abdul Maulud, K. N., Ramli, M. Z., Miskon, M. F., Jeofry, M. H., Mohamed, J., Mohd, F. A., Hamzah, S. B., & Yunus, K. (2024). The impact of climate change on coastal erosion in Southeast Asia and the compelling need to establish robust adaptation strategies. In Heliyon (Vol. 10, Issue 4). Elsevier Ltd. https://doi.org/10.1016/j.heliyon.2024.e25609

[5] Joe, R. J. J., Pitchaimani, V. S., Mirra, T. V. N. S., & Karuppannan, S. (2025). Shoreline dynamics and anthropogenic influences on coastal erosion: A multi-temporal analysis for sustainable shoreline management along a southwest coastal district of India. Environmental and Sustainability Indicators, 27. https://doi.org/10.1016/j.indic.2025.100744

[6] Ismail, I. N., Kamarudin, M. K. A., Saharudin, I. A., Tuan Mohamad, T. S. S., & Sunardi, S. (2025). Assessment of the impacts of coastal development and climate change of fishing communities in Kuala Terengganu, Malaysia. Journal of the Malaysian Institute of Planners, 23(1), 261–272.

[7] Raj, J. K. (1982). Net directions and rates of present-day beach transport by littoral drift along the East Coast of Peninsular Malaysia. Bulletin of the Geological Society of Malaysia, 15, 57–70. https://doi.org/10.7186/bgsm15198206

[8] Rashidi, A. H. M., Jamal, M. H., Hassan, M. Z., Sendek, S. S. M., Sopie, S. L. M., & Hamid, M. R. A. (2021). Coastal structures as beach erosion control and sea level rise adaptation in malaysia: A review. In Water (Switzerland) (Vol. 13, Issue 13). MDPI AG. https://doi.org/10.3390/w13131741

[9] Zainuddin, S. N. H., Ariffin, E. H., Taslin, P. N. A., Dong, W. S., Ramli, M. Z., Abdul Maulud, K. N., Awang, N. A., Nadzri, M. I., Ibrahim, M. S. I., & Ratnayake, A. S. (2024). Sand dune restoration as sustainable natural architectural design for coastal protection along seasonal storm-prone beach. Results in Engineering, 22. https://doi.org/10.1016/j.rineng.2024.102149

[10] Zulfakar, M. S. Z., Ariffin, E. H., Akhir, M. F., & Awang, N. A. (2021). Variation of Seasonal Monsoon Wave-Driven Circulation Pattern in the Lee of Groyne in Kuala Nerus beach. IOP Conference Series: Earth and Environmental Science, 698(1). https://doi.org/10.1088/1755-1315/698/1/012042