Journal of Design and Built Environment
E-ISSN: 2232-1500 |Print ISSN: 1823-4208
https://ejournal.um.edu.my/index.php/jdbe
Special Issue VII, 2025, 17-28

The Impacts of Artificial Coastal Defense on Local Communities: A Case Study of Kuala Nerus, Terengganu

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Article info:
Submission Date: 16th May 2025
Acceptance Date: 17th September 2025

Keywords:
breakwater, coastal defense, correlation, mangrove, local communities

Abstract

Kuala Nerus' shoreline is protected from coastal erosion using artificial coastal defense. Breakwaters, groynes, and revetments are some artificial coastal defenses constructed. However, since 2016, coastal erosion has continued to worsen. This study analyzes the correlation between local communities' perspectives on the sufficiency of artificial coastal defense built and the impacts on economic, social, and environmental aspects. It determines the proposed mitigation measures for coastal protection from the perspectives of the Department of Irrigation and Drainage, the Public Works Department, and the East Coast Region Development Council (ECRDC), Terengganu. Two questionnaire surveys were employed: an online survey conducted with 150 residents along a 3 km coastal strip and a face-to-face interview with nine individuals from the agencies. The data obtained were analyzed using SPSS, Spearman Correlation Analysis, and Descriptive Analysis. The data acquired demonstrated no significant correlation between the perceptions of local communities. The coefficient value obtained was between 0.0 and +-0.2, which is considered a low correlation. Mangrove replanting was the solution that most respondents from the agencies agreed upon.

1.0 INTRODUCTION

Coastal regions are significant socioeconomic centers, supporting nearly 70% of the global population through activities ranging from urbanization to tourism (Abdullah, 1999). However, these critical regions are threatened by an increasing hazard from coastal erosion (Ann, 1996). In Malaysia, nearly 30% of the coastline is eroding, with Terengganu being one of the states most severely affected. Specifically, 63.6% (155.2 km) of Terengganu's coastlines are eroded, particularly in key locations such as Bukit Besar, Kuala Nerus, and Batu Rakit (Ariffin et al., 2018; Bagheri et al., 2024). The National Coastal Vulnerability Index (NCVI) study by the Malaysian government also categorizes this erosion based on its threat to vital economic infrastructure (Ariffin et al., 2019).

Despite attempts to install protective systems, both solid and soft engineering systems, the severity of erosion in areas like Kuala Nerus continues to worsen, especially during the Northeast Monsoon Season. Since 2016, artificial protection systems, such as breakwaters and revetments, have been installed (Bernama, 2016). However, these efforts have not adequately addressed the issue, leaving residents to live in precarious conditions with their homes alarmingly close to the eroding shoreline. This continued deterioration reflects an underlying disconnect: the effectiveness of current coastal defense measures has not been systematically evaluated from the perspective of the resident communities most directly affected.

It is necessary to understand the real issues that Kuala Nerus individuals have faced over the past few decades in order to design better and more sustainable solutions. The ongoing deterioration indicates a significant lack of assessment regarding the existing coastal protection measures, particularly concerning how effective they are perceived to be by the affected communities. Therefore, this study will investigate residents' perceptions of the adequacy of current artificial coastal defense structures and their ensuing impacts on economic, social, and environmental aspects. The research also aims to identify proposed measures for mitigating coastal protection based on perceptions from relevant government departments, including the Department of Irrigation and Drainage, the Public Works Department, and the East Coast Region Development Council (ECER DC) in Terengganu. By synthesizing expert opinions from governmental agencies with the local community perceptions and considering alternatives like beach drainage systems (Beach Management Systems and Pressure Equalization Modules), geotextile breakwaters, and eco-engineering, this paper will serve as a crucial reference guide for the government to act towards more sustainable and efficient coastal protection policies in Kuala Nerus.

2.0 METHODS

2.1 Study Area

The Federal Government proclaimed Kuala Terengganu a city in 2008, geographically dividing it into northern and southern regions by the Terengganu River. The population of the northern region has experienced a significant increase, with approximately 200,000 individuals added since 2008 (Jaharudin et al., 2019). This study focuses on the northern part of Kuala Terengganu, a heterogeneous area with mixed land uses. As shown in Figure 1, these encompass some of the major educational institutions, such as Universiti Malaysia Terengganu (UMT) and Universiti Sultan Zainal Abidin (UniSZA), as well as recreational areas, commercial hubs, and residential neighborhoods like Taman Desa Murni and Kampung Gong Badak. The area also comprises crucial infrastructure, including the Sultan Mahmud Airport and an army camp, and is home to traditional fishing and farming communities in neighborhoods like Kampung Tok Jembal. The study location is bounded into three distinct zones—Zone A, Zone B, and Zone C—on a 3 km long coastal stretch from Tok Jembal Beach to Mengabang Telipot Beach, as clearly outlined in Figure 1. Specifically, Zone A encompasses Tok Jembal Beach and its vicinity. At the same time, Zone B is particularly centered on the Universiti Malaysia Terengganu (UMT) locality and areas of Kampung Gong Badak, which are marked with prominent academic and recreational facilities. Zone C covers the coastal stretch up to Mengabang Telipot Beach, located in the north of UMT. There are also favorite tourist spots, particularly the popular "Miami Beach" of this stretch, which attracts visitors, especially during school and public holidays.

Figure 1. Aerial depiction of the study area (Source: Google Map, 2023)

This study area was chosen because numerous documented erosional incidents have occurred along this stretch, such as the 2010 extension of a 1-km runway at Sultan Mahmud International Airport in Tok Jembal beach (Jaharudin et al., 2019). After the airport tarmac extension was finished in 2010, the erosion levels suddenly intensified, catching the surrounding residents off guard. The residents initially supported the extension of the runway because they commonly use planes for interstate travel, and it transformed their airport from a simple domestic terminal to a world-class international gateway. Unfortunately, this tarmac expansion into the sea (through reclamation) unintentionally caused negative impacts due to the retreating coastline, which had massive implications for the local villages (Ariffin et al., 2019).

2.2 Data Collection

In this study, data were collected from two sources: primary and secondary data. Primary data were collected using two sets of questionnaire surveys. These included an online survey for local communities in the study area, a face-to-face interview with the Department of Irrigation and Drainage's Public Works Department, and an online interview with the East Coast Region Development Council (ECER DC) in Terengganu.

A two-set questionnaire survey was used as a tool for data collection for this study. The first survey consisted of nine multiple-choice questions, five open-ended questions, and 23 questions measured using a Likert scale. The Likert scale-based question consisted of 5 points, ranging from "strongly disagree" to "strongly agree," allowing respondents to indicate their level of agreement (from negative to positive). The questions were organised under four major question categories:

a. Demographic characteristics (age, educational level, occupation) and perception regarding the coastal defence built
b. Social impacts
c. Economic impacts
d. Environmental impact

For this study, a non-probability sampling method had been employed, specifically convenience or snowball sampling, given that the survey was distributed online and participation was voluntary. The initial plan involved using probability sampling; however, the online distribution and voluntary nature of responses rendered this approach unfeasible. The survey aimed to reach individuals directly affected by beach erosion, particularly homeowners and business owners in the impacted neighborhoods. Based on the approximate population of 89,470 residents in Kuala Nerus, Terengganu, a target sample size of 150 residents was considered, referencing a 95% confidence interval, an 8% margin of error, and a 50% distribution rate as a guideline. The online survey was distributed to residents in areas stretching from Tok Jembal Beach to Mengabang Telipot Beach.

A second survey was conducted to gather expert opinions on proposed mitigation measures. This expert-created questionnaire consisted of six multiple-choice questions, seven open-ended questions, and four Likert scale questions. A total of nine representatives from the Department of Irrigation and Drainage (DID) were consulted, given their expertise in erosion and flood management in Malaysia and their role as the primary authority on erosion issues. The expert consultation also included representatives from the Public Works Department and the East Coast Economic Region Development Council (ECERDC) in Terengganu.

To begin with, houses and individuals within 100 meters of the shore that are affected were identified. Four hundred participants were selected to represent 400 households in the coastal area, spanning from Tok Jembal to Batu Rakit. Every one of the data types, including household income, the main reasons for coastal erosion, government prevention measures, the reasons respondents agree with, the reasons respondents disagree with, and future preparedness for erosion, is referenced from Jaharudin et al. (2019).

2.3 Data Analysis

The study utilized a random sample of 150 residents living along a 3 km coastal stretch between Tok Jembal Beach and Mengabang Telipot Beach, complemented by data from nine officials representing the Department of Irrigation and Drainage, the Public Works Department, and the East Coast Region Development Council (ECRDC) in Terengganu. Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS), facilitating the processing and interpretation of survey findings. For the first objective, Spearman correlation analysis was employed to examine the relationship between local communities' perceptions of the adequacy of coastal defenses and their impacts on social, economic, and environmental aspects. This aligns with methodologies discussed by Sukanya et al. (2021), who explored statistical tools to assess community feedback on geo-synthetic seawalls as coastal defenses.

The second objective, focusing on agency opinions regarding proposed mitigation measures, was analyzed descriptively. Descriptive statistics, including mean, frequency, and percentage, summarized demographic characteristics, community-reported impacts of artificial coastal defenses, and related data. This approach, similar to Yee and Chee's (2022) use of descriptive analysis to study community responses to artificial coastal structures, provided a comprehensive understanding of stakeholder perceptions.

Spearman correlation coefficients (r) range from -1.0 to +1.0, indicating the strength and direction of a linear relationship between two variables. Positive values suggest a direct relationship, negative values indicate an inverse relationship, and a value of 0 indicates no correlation. Such statistical methods are crucial in coastal defense studies, as highlighted by Abioye et al. (2021), who examined stakeholder insights on AI applications in construction and their implications for coastal strategies. Table 1 illustrates these relationships, contextualizing the quantitative findings within the study framework.

In this study, even a "weak correlation" is important because it can reveal small links or early signs of factors that affect beach erosion, helping us not to overlook factors that might have a small but significant role in this complex environmental problem. Such weak relationships can highlight the multifactorial nature of beach erosion, justifying further, more granular research or the exploration of confounding variables. Additionally, finding even weak correlations can influence policy and planning, as addressing small contributing factors, even if they are not the primary issues, can still yield benefits within a broader

management approach. Ultimately, understanding weak correlations helps build a more complete picture of the problem and sets realistic expectations for the effectiveness of various mitigation measures.

Table 1. The strength of the relationship estimation between two variables

Coefficient of correlation	Correlation
0.0 to +-0.2	Little correlation
+-0.2 to +-0.4	Weak correlation
+-0.4 to +-0.7	Correlated
+-0.7 to +-0.9	Strong correlation
+-0.9 to +-1.0	Very strong correlation

3.0 RESULT AND DISCUSSION

Coastal erosion at Kuala Nerus is a cumulative issue with many influencing factors, as demonstrated in Figure 2. A majority of 48% of the respondents identified the Sultan Mahmud Airport runway extension as the primary reason. Jaharudin et al. (2019) reports that erosion problems in Kuala Nerus were already present since 2008, during the time of the airport runway expansion. In addition to airport development, 46.7% of the respondents cited inefficient and poor artificial coastal protection. Despite the construction of structures such as groynes and breakwaters, Ariffin et al. (2019) reported that these developments have often been unsuccessful in preventing erosion over time. 42.7% of the respondents identified climate change as the cause.

Furthermore, 34.7% and 26.7% of the respondents identified human actions and industrialization as potential causes, respectively. While natural processes create erosion in some areas, insufficiently planned or poorly situated development along coastlines and coastal regions plays a significant role (Mohamed Rashidi et al., 2021). Awang et al. (2014) concurred, further stating that human-induced alterations along coastlines, such as the construction of structures, cause erosion. While most of these structures—such as revetments, ripraps, seawalls, groynes, and breakwaters—prevent erosion, they ultimately enhance it in others. Burka (Mokhtar et al., 2020) supports this by noting that coastal erosion is often triggered by human activities such as beach and port development, shrimp farming, and offshore oil and gas operations. Chong et al. (2023) also highlighted the use of statistical analysis to study how artificial coastal structures affect marine life, since they can influence marine organisms. Finally, strong waves hitting the coastline were believed to be the cause of erosion by 47.3% of the respondents. Jaharudin et al. (2019) further noted that storms, with their strong winds, waves, and currents, are a definite source of erosion on most coastlines. In short, coastal erosion issues in Kuala Nerus are caused by multifaceted factors, including climate change, human activities, industrialization, strong waves hitting the shore, the extension of the Sultan Mahmud Airport runway, and poor quality and inefficient artificial coastal defenses.

The impact of coastal erosion on local communities' household income is depicted in Figure 3. The results indicate that the issue of coastal erosion had no impact on the majority of respondents, specifically 82 people (54.7%). However, for various reasons, coastal erosion had a negative impact on the household income of 45.3% of the respondents. Additionally, the erosion forced 47 people (31.3%) to relocate and purchase a new house. This corroborates with Chong et al. (2023), who found that 98 respondents (24.5%) indicated readiness to move away if the erosion intensified, and 46 people (11.5%) saw themselves purchasing a new home in the event of such an occurrence.

Kuala Nerus respondents consistently identify inefficient and inadequate artificial coastal defenses as the primary cause of erosion, with 46.7% of respondents highlighting this issue. This finding aligns with broader observations that, although constructions like groynes and breakwaters have been erected, their effectiveness in stopping erosion is found to be lacking within a matter of a few years (Ariffin et al., 2019). The issue is not just in the presence of defenses but also in their long-term performance and geometry, which may be inadequate to face variable coastal processes.

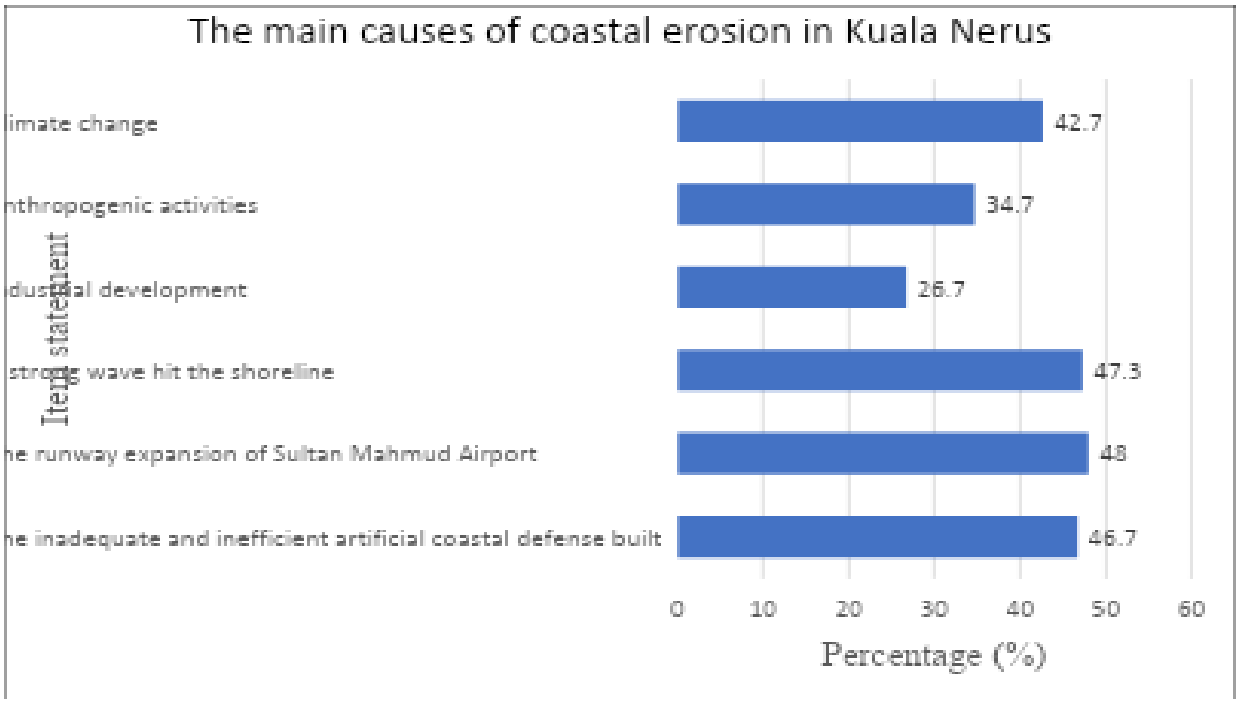

Figure 2. The main causes of coastal erosion in Kuala Nerus

Aside from natural processes, anthropogenic activities (34.7%) and industrial development (26.7%) were commonly cited as causative factors of erosion. This finding strongly correlates with the literature, which highlights the fact that inadequately planned or located development on coastlines can lead to a profound increase in erosion, even in locations where natural processes are already occurring (Mohamed Rashidi et al., 2021). Awang et al. (2014) also support this by explaining how human alterations of coastlines, such as the construction of structures, initiate erosion. Even though structures like revetments, ripraps, seawalls, groynes, and breakwaters are constructed to prevent erosion, their localized impact could sometimes relocate or channel erosive forces elsewhere, a foremost consideration in coastal management.

Such localized knowledge is supported in larger academic literature. Mokhtar et al. (2020) emphasized that coastal erosion is induced by human impacts, such as beach and port construction, shrimp aquaculture, and offshore exploitation, as well as natural phenomena. The complex interaction between coastal defense structures and marine animals, as rigorously studied by Chong et al. (2023), further supports the need for thorough statistical analysis to understand the environmental impact of human activities fully.

Taken together, the results from Kuala Nerus emphasize that coastal erosion is a complex issue driven by an interplay of forces, including climate change impacts (e.g., rising sea levels), human interventions, industrialization, energetic wave actions, the extension of the Sultan Mahmud Airport runway, and weaknesses in artificial coastal protection. Such complex causation calls for holistic and adaptive management strategies.

The breakdown of the influence of coastal erosion on local community household income (Figure 3) indicates a significant, if incomplete, impact. While 82 respondents (54.7%) claimed to be unaffected by coastal erosion problems, a substantial number reported experiencing negative financial impacts.

Specifically, 45.3% of the respondents reported experiencing adverse effects on their household income. Among the respondents, 47 individuals (31.3%) explicitly stated that they needed to relocate and purchase a new house due to coastal erosion. This explicit economic cost of displacement is one of the severe consequences of coastal degradation. This finding is also corroborated by Chong et al. (2023), whose study reported that a substantial proportion of the respondents (24.5%) said they would relocate if erosion worsened, and 11.5% foresaw needing to purchase a new home in such a scenario. Unabated coastal erosion poses a significant threat to large-scale economic and social displacement, as highlighted by the convergence of local experience and aggregated survey data.

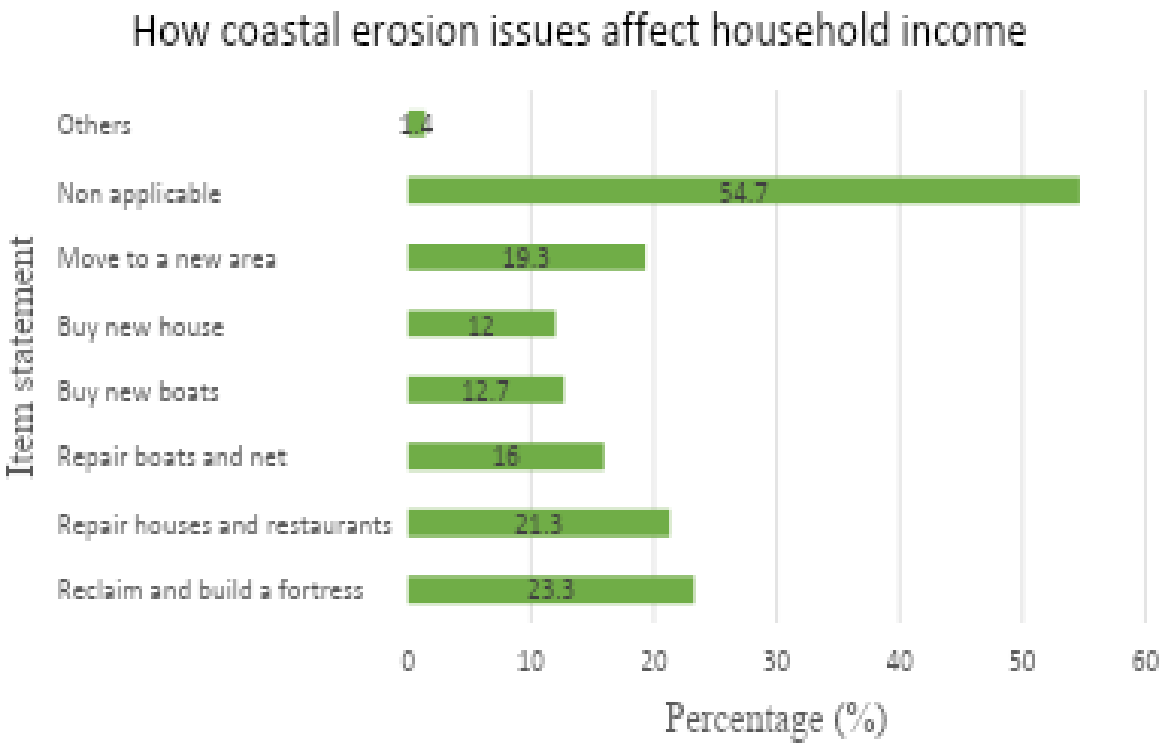

Figure 3. How coastal erosion issues affect household income.

Furthermore, these erosion issues also affected fishermen's household income. A total of 43 people (28.7%) of the respondents had to buy new boats, repair their existing boats, and purchase new nets. The erosion will make it more difficult for fishermen to conduct their fishing operations since it will harm infrastructure, including roads, jetties, homes, and fishing equipment (Muhammad et al., 2016). When the coastal erosion that had previously affected Kampung Tanjung Gelam spread to their locations, some 37 fishermen in Kampung Tengah Mengabang Telipot, Kuala Nerus, were also affected by the same issue. The situation of coastal erosion would indirectly affect fishermen, whose livelihoods are wholly dependent on marine products. Most concerning is that if the erosion issue is not resolved, the buildings housed in the marine product collection will also be lost. Thus, a sand fort was constructed to rescue the Kampung Tengah Fishermen's Welfare Endowment building, which houses an ice water store and a revenue collection facility (Salleh & Nadzir, 2019).

Additionally, 67 (44.6%) of the respondents reported that their household income was affected due to the need to repair houses and restaurants, as well as reclaim and rebuild a fortress. Recently, the owner, Abdul Wahab Othman, 62, stated that severe erosion affected the area of his chalet on the eve of the new year 2022. Before the incident, he planned to build a breakwater at the chalet area in preparation for the monsoon season. He had already purchased necessities such as rocks and other equipment to build the breakwater but did not have time when the waves first stormed the area (Schoonees et al., 2019).

Although the household incomes of more than half of the respondents were affected by the issues, 45.3% of the respondents' futures still require attention. Due to previous coastal erosion, residents living near the shore were the most affected.

3.1 Study Area Correlation Between Local Communities' Perspective on The Sufficiency of Artificial Coastal Defense Built with The Impacts on Social, Economic, And Environmental Aspects

3.1.1 Social Aspects

The Spearman correlation test was used to investigate the relationship between local communities' perceptions of sufficiency in artificial coastal defense and its impact on social aspects. The results are presented in Table 2.

The test of the null hypothesis (H_{01}) was that there is no relationship between perceptions of sufficiency in artificial coastal defense by local communities and their impact on social factors.

As per Table 2, the Spearman correlation coefficient was r=0.085, and the two-tailed significance value was p=0.299. The p-value (0.299) is greater than the typical significance level of 0.05; thus, the null hypothesis (H_{01}) holds. This implies that there is no statistically significant correlation between how local communities perceive the sufficiency of constructed artificial coastal defense and its impact on social components.

Moreover, a correlation coefficient of 0.085 signifies a very weak positive correlation. Although the positive sign indicates that the perspective of local communities on the adequacy of artificial coastal defense increases, the impacts on social factors would also increase slightly; however, this is not a statistically significant correlation. This could imply that, in the context of this study, local people may not consider the sufficiency of coastal defense to be a predominant factor influencing negative social impacts, or that other factors may be more salient.

Table 2. Correlation between local communities' perspective on the sufficiency artificial coastal defense built with the impacts on social aspects

		Social Aspects
Local communities' perspective	Spearman correlation coefficient	0.085
	Sig. (2 tailed)	0.299
	N	150

3.1.2 Economic Aspects

Spearman's correlation analysis was conducted to determine whether there was a significant correlation between locals' perceptions of the artificial coastal defense and its effects on economic aspects. The results are shown in Table 4 below. The first null hypothesis (H0), which posits that there is no significant correlation between local communities' perceptions of the economic effects of artificial coastal defense construction, was tested in the analysis.

Based on Table 3, the correlation coefficient value was r = -0.139, and the p-value was 0.090, which is higher than 0.05. The initial null hypothesis (H0) was accepted since the p-value was greater than 0.05. This demonstrates that there was also no causal connection between how local communities saw the constructed artificial coastal defense and its effects on economic aspects. In addition, the correlation coefficient's value of – 0.139 indicates a slight negative correlation between the residents' perception of the effects of the erected artificial coastal defense and the economic aspects. Furthermore, the correlation coefficient recorded was negative, indicating that the relationship between the two variables was not in the same direction.

Table 3. Correlation between local communities' perspective on the sufficiency of artificial coastal defense built with the impacts on economic aspects

		Economic Aspects
Local communities' perspective	Spearman correlation coefficient	
	Sig. (2 tailed)	0.090
	N	150

From the perspective of local communities, the sufficiency of artificial coastal defense-built increases will decrease economic impacts. This indicated that the residents thought Kuala Nerus' inadequate coastal defense could adversely affect the economy. People are adversely affected by this tragedy in several ways. In addition to damaging nearby homes and businesses, erosion poses a threat to the lives of those who live along the coast.

3.1.3 Environmental Aspects

A Spearman's correlation analysis was conducted to determine whether there was a significant correlation between residents' perceptions of the artificial coastal defense and its effects on environmental aspects. The results are shown in Table 5. The first null hypothesis (H0), which posits that there is no significant correlation between local communities' perceptions of the environmental effects of artificial coastal defense construction, was tested in the analysis.

As shown in Table 4, the correlation coefficient value was r = -0.117, and the p-value was 0.155, which was greater than 0.05. The initial null hypothesis (H0) was accepted since the p-value was greater than 0.05. This demonstrates that there was also no causal connection between how local communities saw the constructed artificial coastal defense and its effects on environmental aspects. Moreover, the correlation coefficient's value of –0.117 indicates a slight negative correlation between the residents' perception of the effects of the erected artificial coastal defense and environmental aspects. Next, the correlation coefficient stated was negative, indicating that the relationship between the two variables was not in the same direction.

Table 4. Correlation between local communities' perspective on the artificial coastal defense built with the impacts on environmental aspects

		Environmental Aspects
Local communities' perspective	Spearman correlation coefficient	-0.117
	Sig. (2 tailed)	0.155
	N	150

The effects on environmental aspects will lessen as residents' perspectives on the sufficiency of artificial coastal defence structures rise. Local communities believe the coastal defence built in Kuala Nerus can impact environmental aspects. Nonetheless, this opinion aligns with Tourlioti et al.'s (2021) study, which found that coastal structures can have a significant impact on shoreline configuration. Artificial structures can divide the coastal space, affecting sediment transport. This may cause habitat degradation and bird disturbance due to noise and visual disruption.

However, no previous studies related to this topic contained a correlation analysis**.** Therefore, from Tables 3, 4, and 5**,** the study can conclude that all these correlations were interpreted as having little correlation, as the r-value (correlation coefficient) obtained ranged between 0.0 and ±0.2 and was not significant, given that the p-value was higher than 0.05.

3.1.4 Proposed Mitigation Measure for Coastal Protection

Figure 4 shows a chart of the percentage of the current shoreline category in Kuala Nerus based on the agencies' answers. The Malaysian shoreline was categorized into three categories of erosion based on the threat to the existing shore-based infrastructure of significant economic significance (Jaharudin et al., 2019). A Category 1 shoreline is in immediate danger of collapse or damage, which needs to be a top priority to manage. Meanwhile, the shoreline of Category 2 will become threatened within 5 to 10 years if remedial action is not taken. Although it has a lower priority, appropriate measures must still be taken. Lastly, a Category 3 shoreline has been experiencing soil loss and erosion, but with no minor consequent economic loss if left unchecked. Most (77.8%) of the total respondents, which comprised seven people, assigned the Kuala Nerus shoreline to Category 1. On the other hand, two of the respondents assigned it to Category 2.

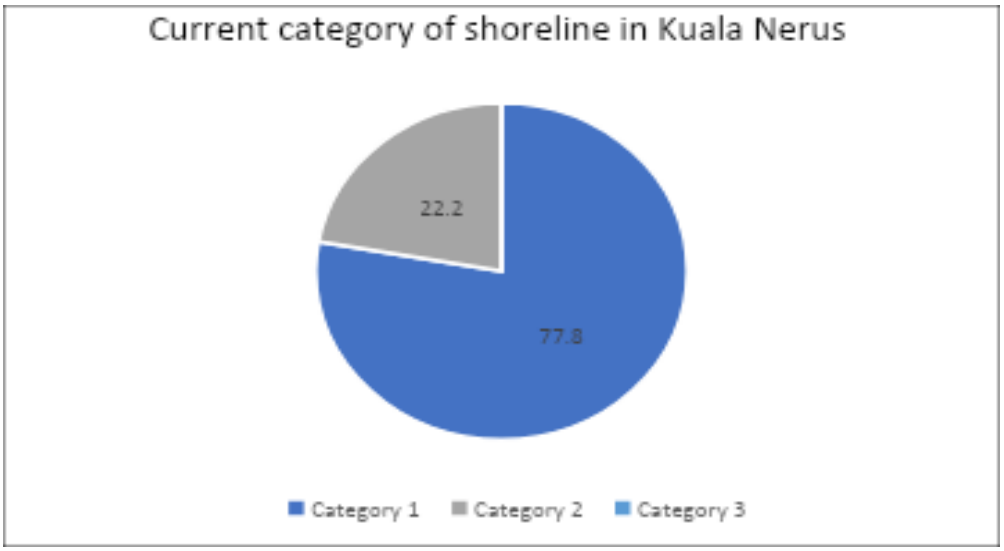

Figure 4. Percentage of the current category of shoreline in Kuala Nerus

Table 5 presents a descriptive analysis of proposed mitigation measures for coastal protection, reflecting the perspectives of the Department of Irrigation and Drainage, the Public Works Department, and the East Coast Region Development Council (ECRDC), Terengganu.

Regarding geotextile breakwaters, the data indicates a mixed reception. While three respondents (33.3%) moderately agreed with its use, and two (22.2%) strongly agreed, along with one (11.1%) who agreed (totalling 66.6% in favour), a significant portion expressed reservations. Specifically, two individuals (22.2%) disagreed and one (11.1%) strongly disagreed, collectively representing 33.3% who disapproved. The mean score for the geotextile breakwater was 3.11, suggesting a slightly above-neutral overall agreement.

Table 5. Descriptive analysis of the proposed mitigation measure

Item Statement	Frequency and percentage scale (%)						Mean
	1	2	3	4	5	Total (N)	
Geotextile breakwater	1 (11.1)	2 (22.2)	3 (33.3)	1 (11.1)	2 (22.2)	9 (100)	3.11
Beach management system	1 (11.1)	1 (11.1)	4 (44.4)	2 (22.2)	1 (11.1)	9 (100)	3.11
Pressure equalization module (PEM)	0 (0.0)	0 (0.0)	6 (66.7)	2 (22.2)	1 (11.1)	9 (100)	3.44
Mangrove replanting	1 (11.1)	0 (0.0)	2 (22.2)	2 (22.2)	4 (44.4)	9 (100)	3.89

The qualitative feedback from respondents highlighted concerns regarding the long-term efficacy of geotextile breakwaters, with some stating that this coastal defense might not withstand prolonged wave action and could be washed away. This apprehension is supported by existing literature, which acknowledges the durability concerns of geotextile sand containers. For instance, observations from Port Dickson, Negeri Sembilan, where a similar sandbag technique was used as a temporary protective measure, demonstrated damage due to ageing (Utusan Timur, 2022). Research also suggests that the use of a non-woven geotextile layer can increase the durability of geotextile tubes against abrasion and UV degradation (Shin et al., 2019).

4.0 CONCLUSIONS

The present research aimed to determine the attitudes of local communities toward artificial coastal protection systems in Kuala Nerus and to identify recommended mitigation measures from key government departments. Our Spearman correlation test did not identify any statistically significant correlations between local communities' attitudes toward the effects of artificial coastal defence construction and social, economic, and environmental factors. The correlation coefficients varied consistently between 0.0 and ±0.2, indicating a very weak or zero relationship.

However, the descriptive analysis provided helpful information, showing that current artificial coast defences in Kuala Nerus influence social, economic, and environmental aspects. Social factors significantly influenced recreational, picnic, and fishing activities of local communities. Economically, the fishery, as well as restaurants and sales businesses near the coast, were worst hit by the negative impact due to the lack of coastal defence. Environmentally, the sectors most concerned with severe issues raised included the erosion of the natural scenery in coastal landscapes, alterations in the form and function of the coastal ecosystem, and the depletion of beaches.

For future mitigation, mangrove replanting to act as coastal defence was contemplated and supported by the Department of Irrigation and Drainage, Public Works Department, and East Coast Region Development Council (ECER DC), Terengganu, as a viable solution to coastal erosion. For future studies, we recommend conducting site-specific and comprehensive scenario analyses with the assistance of state-of-the-art numerical modelling tools to acquire more precise impact assessments for mangrove replanting programs.

Aside from the technical aspects of the design, it is important that stakeholders and the government actively consider and prioritise the opinions of civil society, most particularly the local people in Kuala Nerus. The people's issues and the potential impact on their quality of life, household incomes, and future livelihoods should be central to any planning. Furthermore, all concerned parties must ensure the regular maintenance of coastal defences and take active and timely steps to combat erosion, rather than waiting until disasters occur during the monsoon. Lastly, effective coastal planning and management in advance by concerned agencies are required so that planned protection not only provides security for inhabitants but also preserves the scenic and ecological splendour of the beach for future generations.

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