

Response to Reviewers' Comments

On manuscript Number: **NHESS-2024-176**

Title: Catastrophic beach erosion induced by littoral drift on nearby beach after Samcheok LNG's massive coastal reclamation project

R#: Reviewer number (1, 2); **C#:** Comment/Response number; **A:** Authors' response.

Line number in **Marked** copy of **R1** manuscript: **L#**

Note: Words/phrases/sentences that represent the response to the Editor and Reviewers' comments are highlighted in **BLUE/RED** color in the revised manuscript, while those from our own revision are also typed in **BLUE/RED**.

A **Clean** copy is also produced, upon deleting the parts struck out and retaining only those newly added in **BLUE/RED**.

First of all, the author would like to express sincere thanks to the editor and two reviewers who reviewed this paper. The author responded to all comments individually in the following sections. Please refer to the line numbers in the two reviewers' comments (**R#-C#**) are information about the manuscript before correction and supplementation.

Reviewer #2:

Reviewer #2: A. General Comments G

This study addresses the severe beach erosion at Wolcheon Beach following the Samcheok LNG terminal's large-scale reclamation project. The authors use a shoreline change model, validated with satellite imagery, to analyze the effects of altered littoral drift (LST). The research is highly relevant given the increasing global issue of coastal erosion due to anthropogenic activities and climate change. The study provides valuable insights into predictive modeling and potential mitigation strategies. However, while the study presents strong empirical evidence, some aspects require further clarification, particularly regarding model assumptions, validation methodology, and the applicability of proposed mitigation measures. Below is a detailed critique.

R2-C1: Strengths of the Study Timely and Relevant Topic

- Coastal erosion due to large-scale infrastructure projects is a pressing issue, and the study highlights an extreme case with real-world implications.
- The integration of satellite data and numerical modeling is commendable, as it allows for a robust spatiotemporal analysis.

A2-C1: Thank you for your comments.

R2-C2: Methodological Rigor

- The study effectively uses Google Earth Engine for satellite-based shoreline detection, a reliable method that enhances the spatial resolution of shoreline change assessment.
- The use of the Parabolic Bay Shape Equation (PBSE) to propose mitigation measures (e.g., groins) is methodologically sound and aligns with coastal engineering principles.

A2-C2: Thank you for your comments.

R2-C3: Clear Identification of Impacts

- The analysis clearly demonstrates the severe impacts of the Samcheok LNG reclamation on Wolcheon Beach, substantiating claims with quantitative LST analysis.
- The discussion on wave diffraction effects and their role in exacerbating LST-induced erosion is insightful and well-supported by existing literature.

A2-C3: Thank you for your comments.

R2-C4: Oversimplification of Sediment Transport Processes

- The one-line shoreline change model assumes uniform longshore transport but does not account for cross-shore dynamics (e.g., storm-induced sediment suspension and offshore transport).
- While wave diffraction effects are discussed, the study lacks wave energy dissipation analysis, which could refine the understanding of sediment transport pathways.

A2-C4: As mentioned in Section 5.2, this study focuses more on shoreline reshaping with normal waves rather than coastal retreat caused by storm waves. This is because severe erosion damage at Wolcheon Beach is analyzed to have been primarily caused by the Samcheok LNG terminal. Furthermore, the annual variation in wave climate, as shown in Figure 3, appears to be minimal. This implies that a rough analysis can be conducted by simply estimating longshore sediment transport (LST) based on the average wave climate. For reference, the primary input for estimating LST indirectly considers energy suspension through breaking waves. The comments you provided have been additionally described as limitations in the Discussion section.

R2-C5: Insufficient Discussion of Seasonal and Climatic Variability

- The study acknowledges seasonal variations in erosion rates, but no specific meteorological events (e.g., storms, typhoons) are analyzed to determine their relative influence.
- The role of sea level rise (SLR) and climate-driven changes in wave energy is not addressed. Given the long-term relevance of coastal management, this omission limits the broader applicability of the study.

A2-C5: As explained in detail in **R2-C4**, this study focuses on analyzing the causes of erosion due to the Samcheok LNG terminal. Therefore, factors other than littoral drift were not analyzed in detail. However, recognizing the importance of these factors, we have elaborated on these limitations in the Discussion section.

R2-C6: Mitigation Strategies Require Further Justification

- The proposed groin installation is based on the PBSE approach, which is widely used in coastal engineering. However:
 - The optimal groin spacing and expected sediment retention efficiency are not thoroughly quantified.
 - The authors should discuss potential adverse effects of groin structures, such as down-drift erosion or sediment starvation in adjacent coastal areas.
- Alternative mitigation measures (e.g., beach nourishment, submerged breakwaters) should be compared in terms of cost-effectiveness and environmental impact.

A2-C6: Large-scale coastal development near shorelines can cause significant topographical changes to adjacent coastal areas. In many cases, economic priorities take precedence, making it impossible to halt development even in coastal areas with high conservation value. Therefore, this study proposes a solution using a hard engineering method, which, despite its drawbacks, is the most direct and effective approach to preventing critical topographical changes and sand loss.

Furthermore, in hard engineering, beach nourishment is unnecessary, as the sand that needs to be preserved already exists. Among the various functions of coastal structures, a groin has been suggested in the discussion as a means to mitigate sand loss caused by littoral drift. Additionally, the considerations of cost-effectiveness and environmental impact are regarded as separate and complex topics that fall beyond the scope of this study.

These details have been further explained in Section 6.2 of the discussion.

R2-C7: Recommendations for Improvement

Expand Discussion on Mitigation Strategies

- Justify groin placement and spacing with numerical simulations of sediment retention efficiency.
- Compare the effectiveness of groins vs. beach nourishment vs. submerged breakwaters in mitigating erosion at Wolcheon Beach.
- Discuss potential negative consequences of groin installation.

A2-C7: As per your advice, we have added a detailed discussion on groins to mitigate severe erosion damage caused by the installation of the Samcheok LNG terminal at Wonpyeong Beach. In particular, numerical results are presented for cases where submerged breakwaters (considering their locations and number) were installed to mitigate erosion damage in areas other than the estuary. Additionally, it was discussed that if the groin's protrusion length is too large, it may cause negative effects due to additional wave deformation.

Regarding the efficiency of each method, additional discussions were made on whether groins are more appropriate than beach nourishment, as detailed in **A2-C6**. Furthermore, it was determined that submerged breakwaters are not a suitable method as they do not block littoral drift.

R2-C8: This study provides important insights into the consequences of large-scale coastal reclamation on sediment dynamics. The integration of satellite-based shoreline change detection with numerical modeling is a significant strength, and the proposed mitigation strategies are valuable for coastal engineers and policymakers.

However, to improve its impact and applicability, the study should:

I suggest replacing the adjective "catastrophic" with an equivalent, such as "substantial". I also suggest clarifying which variables contribute to the RMSE, which also assumes non-negligible values. Expand the discussion on the limitations of the method and discuss the uncertainty associated with the proposed solutions.

A2-C8: Based on the comment from the two reviewers, the title of this paper has been revised as follows:

Severe beach erosion induced by shoreline deformation after a large-scale reclamation project for Samcheok LNG terminal in Korea

Additionally, considering the various suggestions made by Reviewer 2, a section explaining the limitations of this study has been added to the Discussion section.