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# Hydrodynamic regimes and proposed structure for flood drainage and navigation stability in Thuan an estuary, Vietnam

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## Abstract

Thua Thien Hue province is significantly affected by conditions of climate change and sea level rise. Located in central Vietnam, the province experiences various climate-related challenges that have a strong impact on its environment and communities. Furthermore, the complexity of hydrodynamic regimes at main estuaries is reasonably challenge for the development of socio-economic, especially in water transportation. As a large estuary of Thua Thien Hue province, Thuan An play a special role in flood drainage and waterway navigation of Huong River. Therefore, understanding the hydrodynamic regime of Thuan An estuary is crucial due to the continuous alterations in its morphology during monsoon seasons. Sedimentation within the estuary creates obstacles for the river mouth entering channel, while erosion affects the northern and southern coasts. These changes have direct implications for flood drainage and waterway navigation. To gain insights into the hydrodynamic regime, this study focuses on further interpretation the hydrodynamic regimes in Thuan An inlet using Delft3D model combined with ArcGIS tools. By combining scientific modeling and practical implications, this study contributes to a better understanding the hydrodynamics of Thuan An estuary, ultimately facilitating sustainable development and management of this vital waterway system. Importantly, proposed structure for flood drainage and navigation stability in Thuan An estuary is considered with the elongation of 2 jetties. The proposed measure shows that the flood drainage is insignificantly affected and the water level at mostly locations in the river is not changed.

**Keywords:** Central Vietnam, Delft3D, Hydrodynamic regime, Thua Thien Hue, Thuan An estuary, Training works, Tropical cyclones, Water transportation.

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## Contents

**Contribution of this paper to the literature**
This study provides the measure of elongated 2 jetties for flood drainage and navigation stability in Thuan An estuary, Vietnam based on deeply understanding the hydrodynamic characteristics. The proposed measure illustrates the flood drainage is insignificantly affected and the water level at mostly locations in the river is not changed.

# 1. Introduction

The development of spits leading to the closure of the inlet or river has significant consequences for water exchange and both commercial and recreational navigation. The accumulation of sediment in the estuary not only hampers waterway transportation but also contributes to obstructive flooding, resulting in downstream river basin inundation [1]. Thuan An estuary has been strongly deposited by sandspits developed from the north and south of the estuary banks. Even though 2 jetties at the north and south banks of the estuary are built up since 2015, the sediment process at the channel of the estuary has been still happening. The deposition of sediment directly affects flood drainage and waterway navigation as well as causing disturbance in socio-economic development [2].

Huong River in Thua Thien Hue province flows into the East Sea through Tam Giang lagoon before to Thuan An estuary located ini Thua Thien Hue province. Thuan An estuary serves as the connection between the Huong River and the sea. It is a wave-dominated estuary situated in a microtidal, wave-dominated coastal environment. The coastal area is significantly influenced by the seasonal monsoon regime with large northeast waves from October to March and calm southeast waves from April to September each year. As a result, the morphology of the entrance to Thuan An estuary undergoes dynamic seasonal changes due to the distinct variations in the direction of wave-induced longshore sediment transport between the two monsoon seasons [2].

The sediment process at the estuary is influenced by various factors, including wave characteristics, river flow, and sediment supply from nearby beaches. To understand and identify the factors that control the development of spits and estuary sedimentation, a combination of observations and mathematical modeling is employed. In order to overcome the limitations of field measurement data, remote-sensing technologies utilizing freely available satellite images are utilized. These long-term and widespread satellite images cover a vast majority of locations on Earth.

To simulate the sedimentation and morphological changes at Thuan An estuary, the Delft3D numerical model is employed. This model allows for the accurate representation of sedimentation processes and the dynamic evolution of the estuary's morphology. By utilizing this numerical model, researchers can gain valuable insights into the sedimentation patterns and the resulting changes in the estuary's shape over time. This information is crucial for understanding the impact of sedimentation on flood management, waterway navigation, and the overall stability of the estuarine ecosystem.

Sedimentation at the estuary is dependent on several factors, such as the wave characteristics, river flow, and sediment supply from the adjacent beaches. Factors controlling the development of spits and estuary sedimentation can be identified through observations and mathematical modelling. The remote-sensing technologies with free satellite images, available in the long-term, and cover most places on earth is used in favor of the limited field measurement data. The Delft3D numerical model is used to simulate the sedimentation and morphological change at the Thuan An estuary.

The proposed measure to address the sedimentation issue in Thuan An estuary involves the elongation of the existing jetties at the north and south banks. It is essential that these measures are designed and implemented in harmony with the surrounding natural environment rather than conflicting with it. To achieve this, a deep understanding of sediment transport processes in morphological systems is crucial [3] The primary objective of this study is to have a comprehensive understanding of the current hydrodynamic regime in the estuary. The hydrodynamic model Delft3D has been utilized, utilizing observation data as input. Through simulations, the model assesses the hydrodynamic conditions under the existing situation and different scenarios considering the proposed structure solutions. It is noted that the impacts of the proposed structure in stabilizing the coastal area surrounding the estuary are considered. The aim is to mitigate sedimentation in the navigation channel and enhance the flood drainage capacity through Thuan An estuary. By studying the effects of the proposed structure, effective solutions can be developed to maintain the stability of the estuary's geomorphology.

By analyzing the outcomes of these simulations, researchers can evaluate the effectiveness of the proposed structure in stabilizing the estuary and reducing sedimentation. This analysis provides valuable insights into the feasibility and potential impacts of the proposed measures, enabling the development of informed and effective strategies for managing sedimentation and enhancing the overall functionality of Thuan An estuary.

# 2. Materials and Methods

## *2.1. Materials*

The temporal remote sensing satellite data including Landsat TM (Thematic Mapper) and Landsat OLI (Operational Land Imager) are used for assessing shoreline changes. The Landsat imagery is freely downloaded from the US Geological Survey web site (http://glovis.usgs.gov/). Furthermore, the images of Landsat in Thua Thien Hue province (path 125/row 49) taken from 1999 to 2023 are downloaded with a spatial resolution of 30m.

For this study, the bathymetry data at a scale of 1: 5,000 for Thuan An estuary is surveyed by the Vietnam Academy for Water Resources in 2023, combined with the topographic maps of 1:50,000 to 1:10.000 scale for coastal areas published by Ministry of Natural resources and Environment of Viet Nam. Figure 1 presents the study area with the positions of currents and wave characteristics.

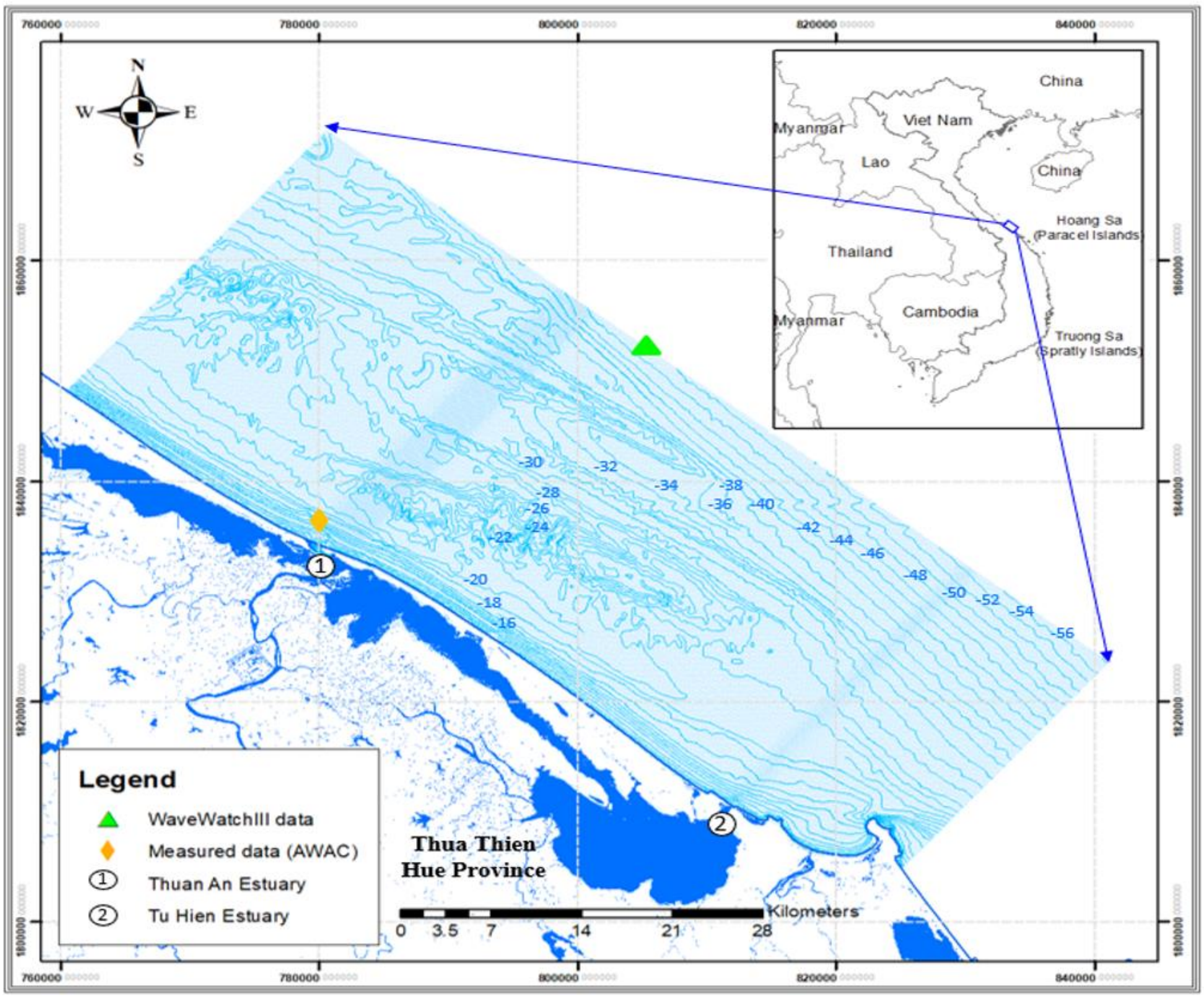


**Figure 1.** Thuan An estuary in Vietnam map and positions of discharge measurement (Q); Water level, wave, currents (NL).

## 2.2. Methods

### 2.2.1. Coastline Analysis

ArcGIS software (ESRI) is used for coastline extraction from remote sensing data. The shoreline is precisely identified through the process of handling remote sensing images. The boundary between land and sea in the classified image is converted into a vector file and needed a manual edit whereby the inland features not related to the shoreline are removed [4].

### 2.2.2. Delft3D FM Model

The numerical model Delft3D based on the depth-averaged model is used to simulate the hydrodynamic and morphological changes of Thuan An estuary [5]. Grid of the model is orthogonal curved with cell size varying from higher resolution in the river mouth and coastal areas and to lower resolution in offshore to increase the model accuracy and reduce computation time consuming. Importantly, the grid extended from 4.5 km upstream of Thuan An estuary to the location of Thao Long bridge on the Huong River and through Thuan A river mouth about 30km into the East Sea to a depth of 40m. The grid is set to ensure that nodes along the open boundary are placed at the National Oceanic and Atmospheric Administration (NOAA) wave data position. Domain of the model consists of 150,132 grid cells.

Model boundaries are designed as (i) Thuan An estuary uses discharge boundary (Q ~ t) from the calculation results of the Huong River network model Mike11 for river boundaries (ii) for offshore boundaries, the offshore limit is defined by the position of the WAVEWATCH III (WW3) data used as offshore forcing boundary conditions for the model including both of water level and wave boundaries [6]. Also, the open boundary water level used the tides available by Ocean TOPography Experiment (TOPEX) global model (http://g.hyyb.org/archive/Tide/TPXO/TPXO_WEB/global.html). TPXO7.2 is one of the most recent versions of global tide with high resolution of 0.25 degree which provide tidal water level for eight constituents (M2, S2, N2, K2, K1, O1, P1, and Q1) [7]. The hourly water levels interpolated to several points along the offshore open boundary. The hourly wave variables are retrieved from the WW3 global model (https://polar.ncep.noaa.gov/waves) with resolution 0.50 degree; including significant wave height, wave direction, and peak wave period. Reanalysis wind data including, U-velocity, V-velocity components, and pressure parameters obtained from NOAA (https://polar.ncep.noaa.gov), are used in this study.

The sediment transport and morphodynamic computations are carried out by means of the Delft3D-SED module. The updated expression of the TRANSPOR2004 formula [8, 9] is used to calculate the bed load and suspended sediment transport. The bed shear stress calculation is based on the Van Rijn [8] roughness predictor. The sediment is sandy with a measured median grain size about 0.2 mm a sediment density equal to 2.650 $kg.m^{-3}$. The dry bed density is set as equal to 1.600 $kg.m^{-3}$. The suspended sediment at the beginning of the computation had a representative diameter equal to the $d_{50}$ value. A minimum water depth equal to 0.2 m is assumed for the sediment transport calculation. The model is set to allow 12 to 24h for hydrodynamic spin up before they executed the bed-level changes.

### 2.2.3 Existed Jetties Structures and Elongation Proposal for Thuan an Estuary

The wave and longshore current cause sediment transport along the Thuan A coast, and it moves sediment into the estuary causing estuary sedimentation, which hamper flood drainage and waterways navigation. Engineering structures are required to stabilize the shoreline and inlets, to reduce sedimentation and to increase the channel depth to allow marine navigation and flood drainage through Thuan An estuary.

Thuan An estuary has a very important role for navigation and flood drainage so the engineering construction must meet both above requirements. The engineering construction must be based on the following criteria: 1) Engineering construction must ensure the river mouth have full capacity to discharge the designed flood (without reducing the flood discharge or significantly increasing the water level of the designed flood). 2) The engineering construction must meet the requirements of waterway navigation. To achieve these goals, 2 jetties at south and north estuary banks are constructed in 2010 with 705m and 642m long (red colour structures in Figure 2). Due to existing of sediment, the prolongation of the jetties (yellow jetties part in Figure 2) is proposed to prevent sand moving into estuary channel from both north and south sides of the estuary. These jetties have a task to concentrate river flow for stabilizing the navigation channel, thus it required that the jetty spacing should not be too narrow, allowing full flood drainage capacity during the flood season. The length of the jetties should extend beyond the littoral transport zone.

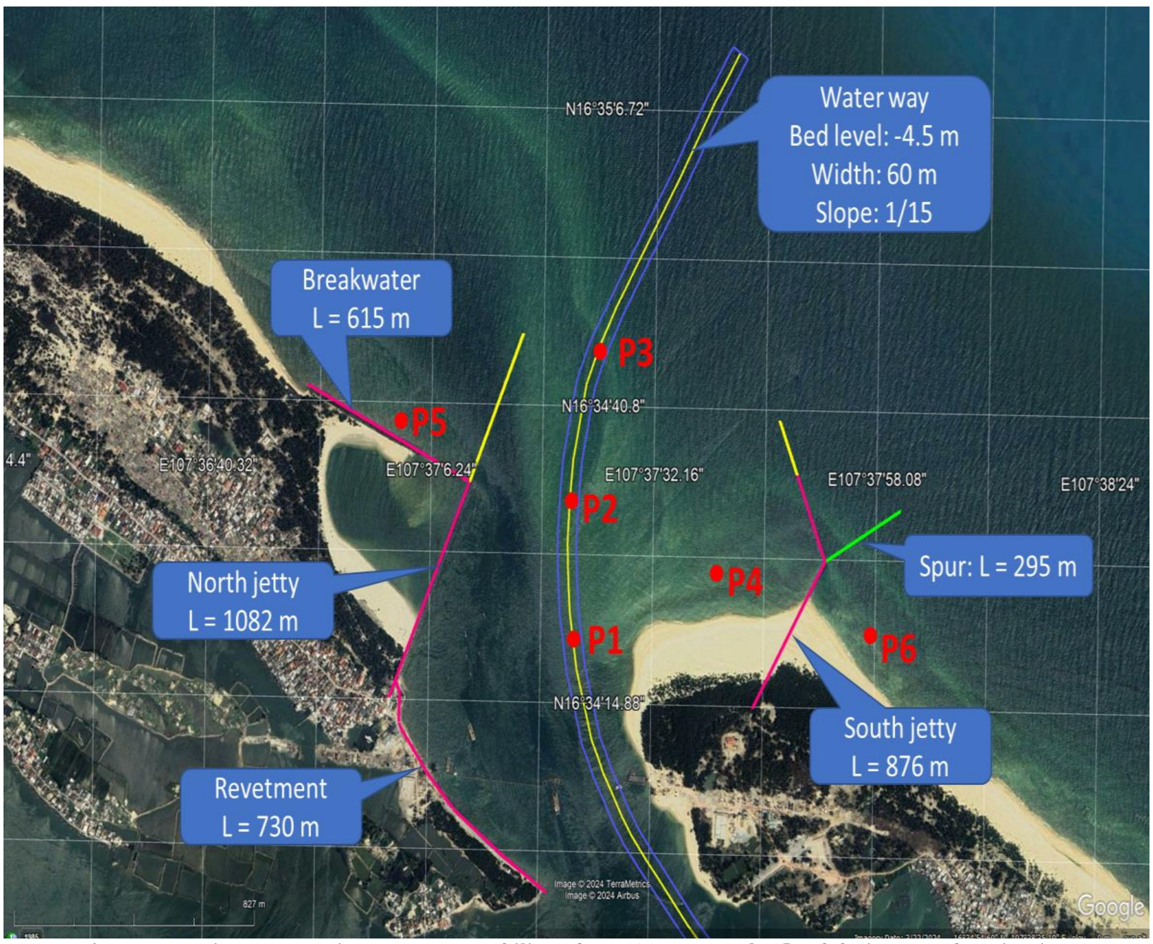


**Figure 2**. Jetties construction system to stabilize Thuan An estuary for flood drainage and navigation.

The prolongation of two jetties is proposed to reach bathymetry elevation of -4.5m, which is natural seabed elevation that maintaining for waterway transport. The elongation of the south and north jetties are 160 m and 440 m long respectively. The distance between the heads of the 2 jetties is 900 m. The estuary channel is dredged to the level of -4.5 for waterway navigation

### 2.2.4 Different Scenario Design and Simulation

The hydrodynamics regime at Thuan An estuary area varies seasonally. Flow and wave regimes for northeast and southwest seasons strongly affect the estuary and coastal areas vicinity. Currents induced by seasonal waves caused sediment transport along the coast to deposit at estuary channels which creates obstacles for navigation and flood drainage through the estuary channel. Thus, calculation scenarios could be selected for seasonal waves and designed flood to facilitate the proposed measure of the estuary stabilized construction.

Hydrodynamics boundary condition in whole year 2017 is selected for accessing the hydrodynamics regimes of Thuan An. In this year, there are 16 storms and depressions happening in central coast of Vietnam. There are also 2 floods events from river occurred in Huong River and its branches in this year.

To calculate structures, hydrodynamics boundary condition of flood event with 2% frequency is selected for accessing the flood obstruction effect of proposing structure to flood drainage capacity (2% flood frequency is regulated by Vietnamese law to this river system).

Boundaries data of scenarios are presented in Table 1. The purpose of each scenario is given as follows: scenario SC1, SC2 is used to assess the hydrodynamics regimes (flow, wave) and morphological change around the estuary in the Northeast monsoon and Southwest monsoon seasons in June 2017 and November 2017, respectively. These hydrodynamics regimes interact with scenarios of the estuary existing condition and proposed structures. It is noteworthy that in this study, the labels of PA0 and PACT stand for estuary existing condition and proposed structures, respectively. The scenarios SC3 has been used to assess the obstruction impact of the proposed structure to the estuary flood drainage.

**Table 1.** Summary of model simulations.

| Scenarios name | Hydrodynamics | Proposed structure system | Purposes |
|---|---|---|---|
| SC0 | Hydrodynamics boundary condition in whole year 2017 | Existing estuary condition (PA0) | Access the hydrodynamics regimes of Thuan An |
| SC1 | Hydrodynamics boundary condition in June 2017 | Proposed structure system (PACT) + dredging channel | Access the hydrodynamics and morphological change around the estuary in the Northeast monsoon with proposed structure system |
| SC2 | Hydrodynamics boundary condition in November 2017 | Proposed structure system (PACT) + dredging channel | Access the hydrodynamics and morphological change around the estuary in the Southwest monsoon with proposed structure system. |
| SC3 | Hydrodynamics boundary condition of 2% flood event | Proposed structure system (PACT) + dredging channel | Access the flood obstruction effect of proposing structure to flood drainage capacity |

To access the ability of reducing wave, preventing sediment moving into estuary channel, flood drainage capacity, the values of wave height, current velocity and water level are extracted at 6 locations (P1, P2, P3, P4, P5, P6) in Figure 2 for comparing between model scenarios.

## 3. Results and Discussions

### *3.1. Calibration*

For the purpose of model calibration, the study used water level, current, and wave data measured from April 10, 2023 - April 15, 2023.

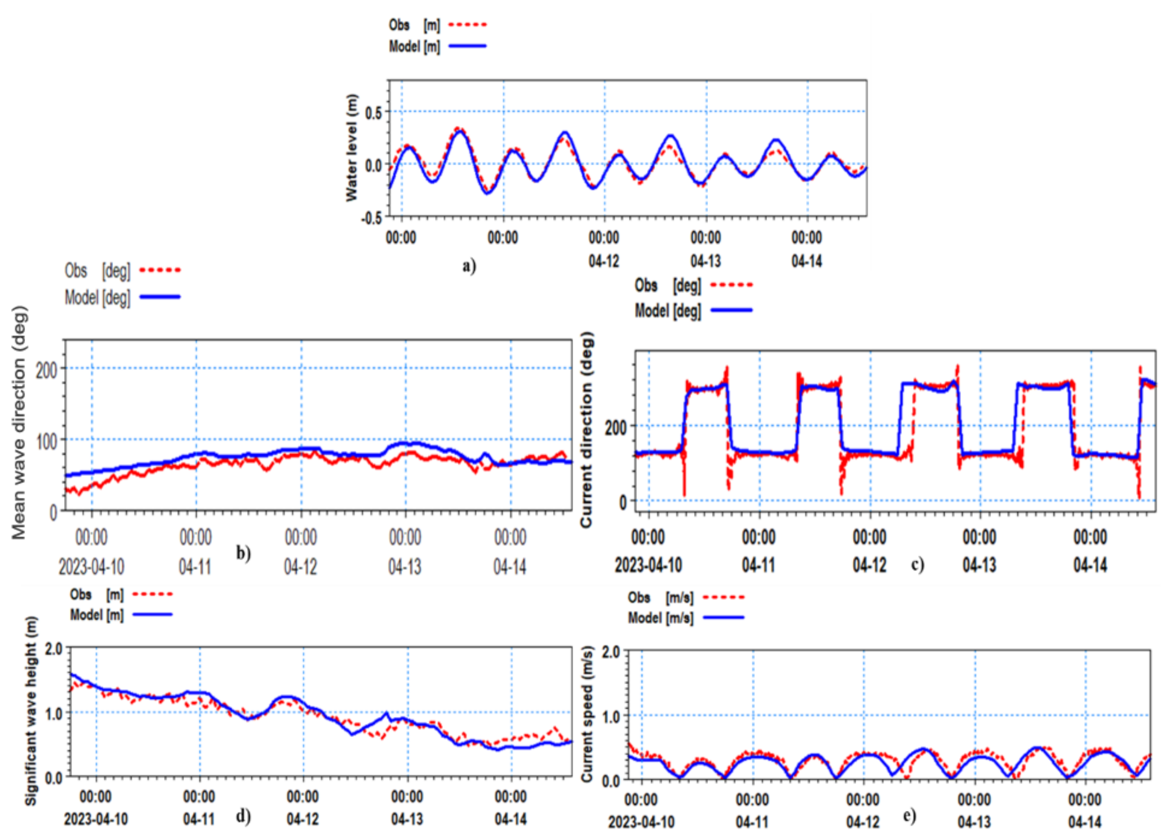


**Figure 3.** Calibration of hydrodynamic model for water level (a), current magnitude (b), current direction (c), water height (d) and wave direction (e).

The calculation results of water level (H), current velocity (V), current direction, significant wave height (W) and wave direction are compared with that of observed data. Figure 3 (a, b, c, d, e) shows the small magnitude of discrepancies. Model performance is evaluated using error statistics such as root mean squared error (RMSE), it is frequently used to measure of the size of the discrepancies between the values predicted by a model and the observed data.

The RMSE index for comparisons of water level, current and waves between calculated and actual measured results are 0.07, 0.1, 0.11, respectively. Thus, the results of water level, currents and waves calculation are basically consistent with the observed data at the Thuan An estuary despite some discrepancies. Based on the findings, it can be stated that the numerical model effectively captures and describes the behavior of currents, waves, and water levels with a reasonable level of accuracy.

### *3.2 Coastline Changes in the Thuan an Estuary*

The evaluation of shoreline changes in the Thuan An estuary area from 1999 to 2023 is divided into two distinct periods. The first period spans from 1999 to 2015, during which Thuan An estuary did not have any jetty structures. The second period covers the years 2015 to 2023, during which jetty structures are implemented in the Thuan An estuary. The position of the shoreline from Landsat images taken in 1999, 2020 and 2023 show that the shoreline changes in the Thuan An estuary during the entire period 1999-2023 is generally described as there is a regularly erosion and retreatment towards the mainland, the sandspits extended into the entrance of Thuan An estuary channel for the northern coastline during 1999. Due to the development of sandspits on both banks, the average width of the river mouth is only about 350m. Especially, the southern coastline extends further into the sea when compared to the northern coastline. Additionally, there is a tendency for erosion along the coast, resulting in a gradual movement of the sandspit towards the entrance of the estuary. After 2 jetties are built at both estuary banks in 2015, the coastlines in vicinity of estuary became stable. In the year 2020, the northern coastline is accreted toward the sea about 150 - 200 m; The southern coastline is most accreted towards the sea about 150 m at the location close to the southern jetty (Figure 2). It is noted that the insufficient length of the jetties has led to the ongoing movement of the southern sandspit towards the entrance of the estuary. Comparison coastal line position of the year 2023 with coastal line of the year 2020, the northern coastline at 2023 is maintained stable and accreted with a maximum of about 50 - 80 m wide. The southern coastline is accreted the most about 50 m at the location close to the southern jetty (Figure 2). The river mouth width is expanded and maintains an average width of about 450 - 500 m.

Figure 4 depicts the shoreline changes in Thuan An during 1999-2023. It can be observed from this figure that there has been a significant change in the width of the sandspits at both the northern and southern banks of Thuan An estuary after building the jetty structures in 2015. The coastline in the Thuan An estuary has been developed by accretion towards the sea, except for the section at the end of the northern sandspit where the coastline has been retreated. The northern coastline of Thuan An estuary is frequently eroded in the past (strong erosion occurred on the coastline in Thai Duong village), but after having a breakwater and jetty structures, it has been accreted and stabilized. The width of the river mouth has been remaining relatively stable. However, the southern coastline continued to be accreted at a strong rate with large volumes of sand transporting from the south by the longshore current into the river mouth.

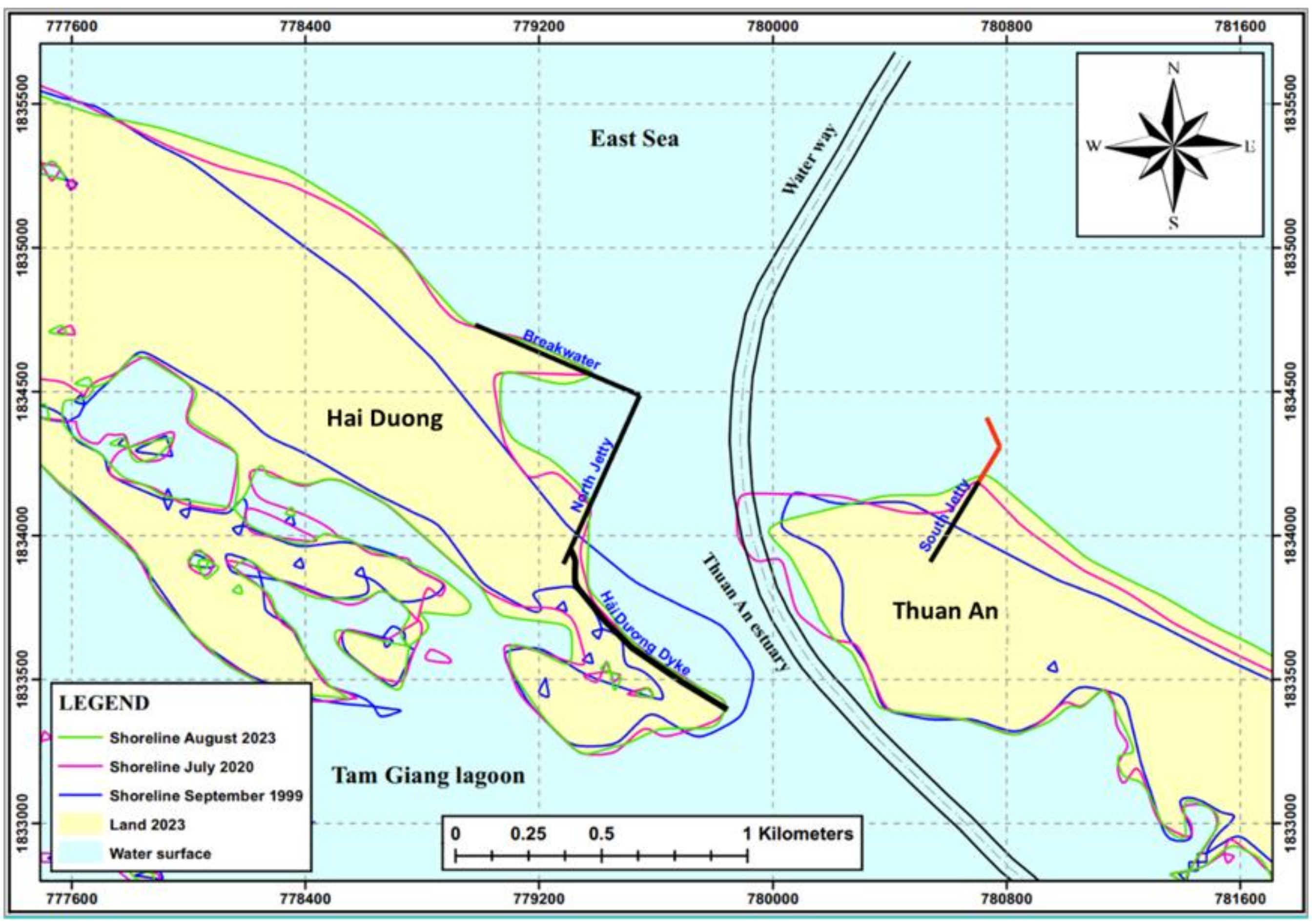


**Figure 4.** Shoreline change in Thuan An estuary area in the years 1999-2020-2023.

### *3.3. Sedimentation Mechanism of Thuan an Estuary*

To understand the sedimentation mechanism at Thuan An estuary, analysis of hydrodynamics regime at Thuan An estuary is carried out. Hydrodynamic modeling results of the year 2017 are used (scenario SC0 in Table 1). Wave heights and current flows are extracted at three points at the estuary: P1 in the northern site, P2 in middle, P3 in the southern site (Figure 5).

The magnitude of tide in the study area is about 0.5-0.6m. The wave fields in the Thuan An estuary area are shown in Figure 5. The Northeast wave direction is the dominant wave direction in this area with wave heights ranging from 0.3m to 2.5m in the coastal area. Wave height during the southwest monsoon period from April to September mainly ranges from 0.3m to 1.2m with an east-northeast wave direction. During the Northeast monsoon period from January to March and from October to December, the wave height is much higher than the wave height during the southwest monsoon period, ranging from 0.5m to 2.5m with the northeast wave direction. Thus, the coastal wave height in the Thuan An estuary area has a large difference between the two seasons in a year with higher wave happened in Northeast monsoon than in Southwest monsoon season.

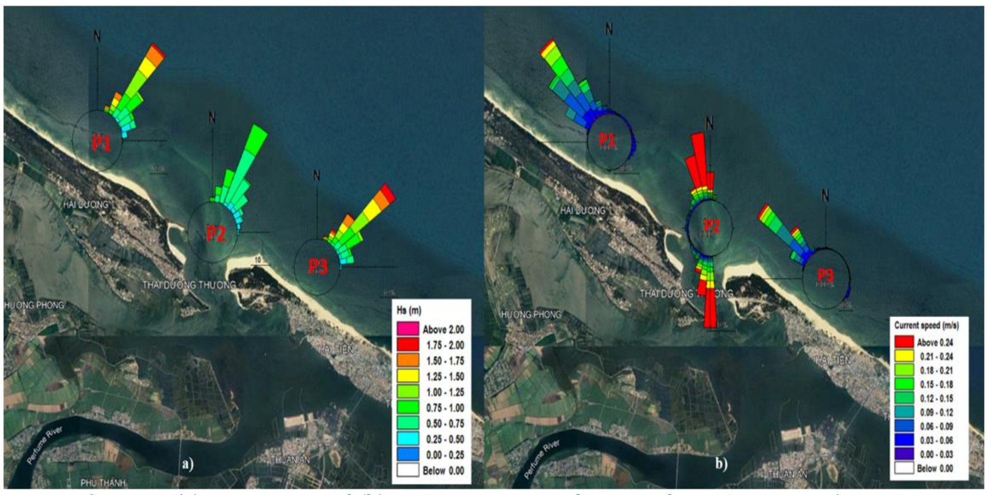

**Figure 5.** (a) Wave rose and (b) current rose near shore at Thuan An estuary in 2017.

At points P1 and P3 are the North and the South bank area of Thuan An estuary; The flow velocity at the South bank tends to be higher than the flow at the North bank. During the southwest monsoon from April to September, the flow speed can reach 0.2m/s. During the Northeast monsoon, the flow velocity is higher than during the Southwest monsoon, ranging from 0.1m/s to 0.43m/s. Thus, the flow velocity in the Northeast monsoon is greater than the Southwest monsoon. At point P2 (river mouth area), the flow velocity is in the North - South direction with flow speeds ranging from 0.1m/s to 0.55m/s.

From the results of hydrodynamic analysis, it shows that during the Northeast monsoon period, with large wave heights ranging from 0.5m - 2.5m, large coastal currents move from South to North carrying a large amount of sand and mud causing sedimentation in the Thuan An estuary area. There is also the influence of the flow from the Huong River; In flood season, flood flow carries out mud and sand from upstream to the river mouth. Because of large waves, tidal currents and river mouth width sudden expansion the sand and mud deposited. Thus, the sedimentation at Thuan An estuary is caused by two main factors: wave and current flow during the Northeast monsoon period combined with flood flow carrying sediment and sand from the river.

### *3.4 Seasonal Wave and Current Regime*

As showed in Figure 6, wave regime during the southwest monsoon period including wave heights in existing estuary condition (PA0) and proposed structure (PACT) are from 0.1m - 0.16m. The southern jetty shields the waves propagate into estuary thus, wave height in proposed structure is lower than wave height in existing condition about 20%-30% when going into the estuary (point P1, P2 and P4). During the northeast monsoon, the northeast wave propagates directly into the river mouth, so the wave height between the PA0 and the PACT are approximately the same, with an average wave height from 0.16m to 0.29m.

Thuan An estuary has very small tidal fluctuations (tide amplitude is about 0.4-0.6 m, this is area where tide amplitude is smallest along coast of Vietnam), so the current velocity at the estuary is significantly small, that ranging from 0.1m/s to 0.3m/s. Current velocity at points P1, P2, P3, P4 in the estuary channel are increased due to the effect of narrowing channel width, caused by jetties existence. Current speed at point 2 increases 2 times in PACT compared to the current speed. The decrease trend of current speed happened with flow outside of estuary channel, at point 5 and point 6. The current speed of PACT is less than that of PA0 at point 5 and point 6 for both periods of northeast and southwest monsoon.

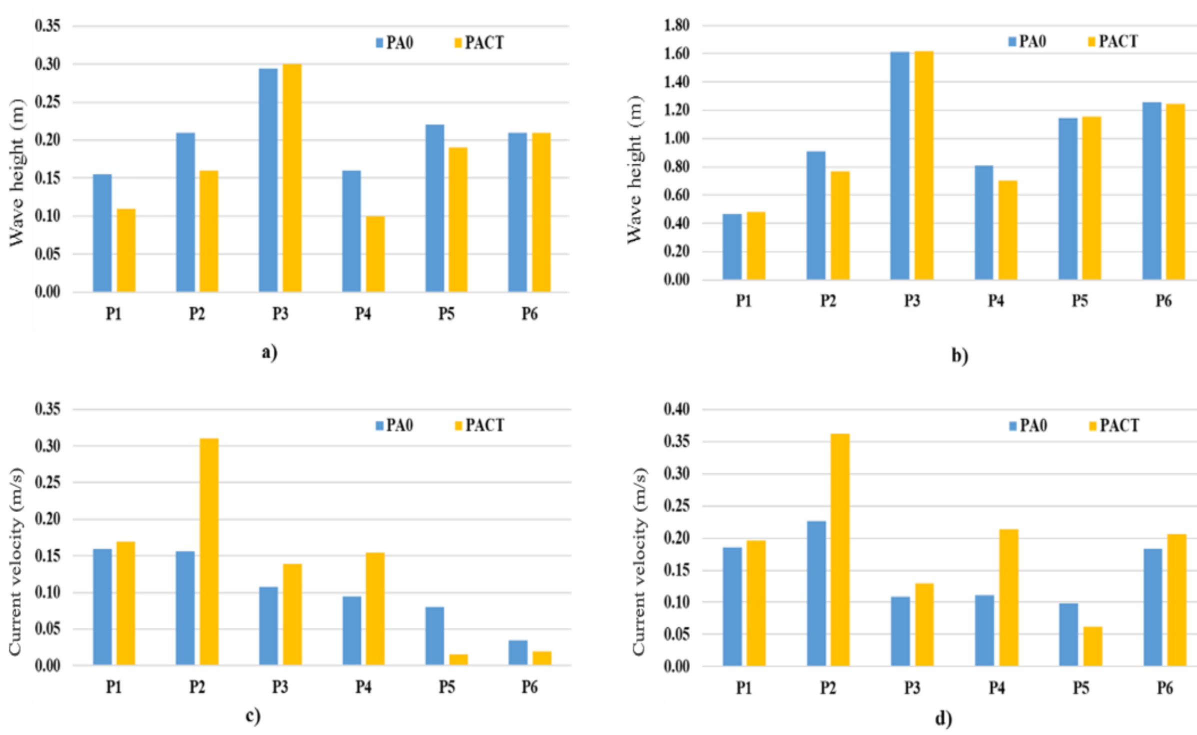


**Figure 6.** Comparison between different cases for wave height in southwest (a) and northeast (b) monsoon and for current velocity in southwest (c) and northeast (d) monsoon.

### 3.5. Seasonal Morphological Change

Seasonal variations in seabed topography are shown in Figure 7. During the 1 month in southwest monsoon season, the seabed at Thuan An estuary area has a little fluctuation. The strongest impact is in the channel area of the PACT with an erosion and deposition of about -0.15m. With the existing condition, the sedimentation is very small and insignificant. During the Northeast monsoon: large waves combined with stronger floods flowing from the river, the seabed of Thuan An estuary fluctuates quite strongly. A sand bar has been formed at the river mouth with an accumulation of up to 0.8m, affecting navigation and flood drainage in the existing condition PA0. In case of structure measure, the average channel bed accumulation is about 0.4m, alternating with erosion about -0.4m, thus the deposition layer in proposed structure is much less than that of the existing condition. This proved the efficiency of the proposed structure to reduce deposition in the estuary channel to promote the flood drainage and waterway navigation.

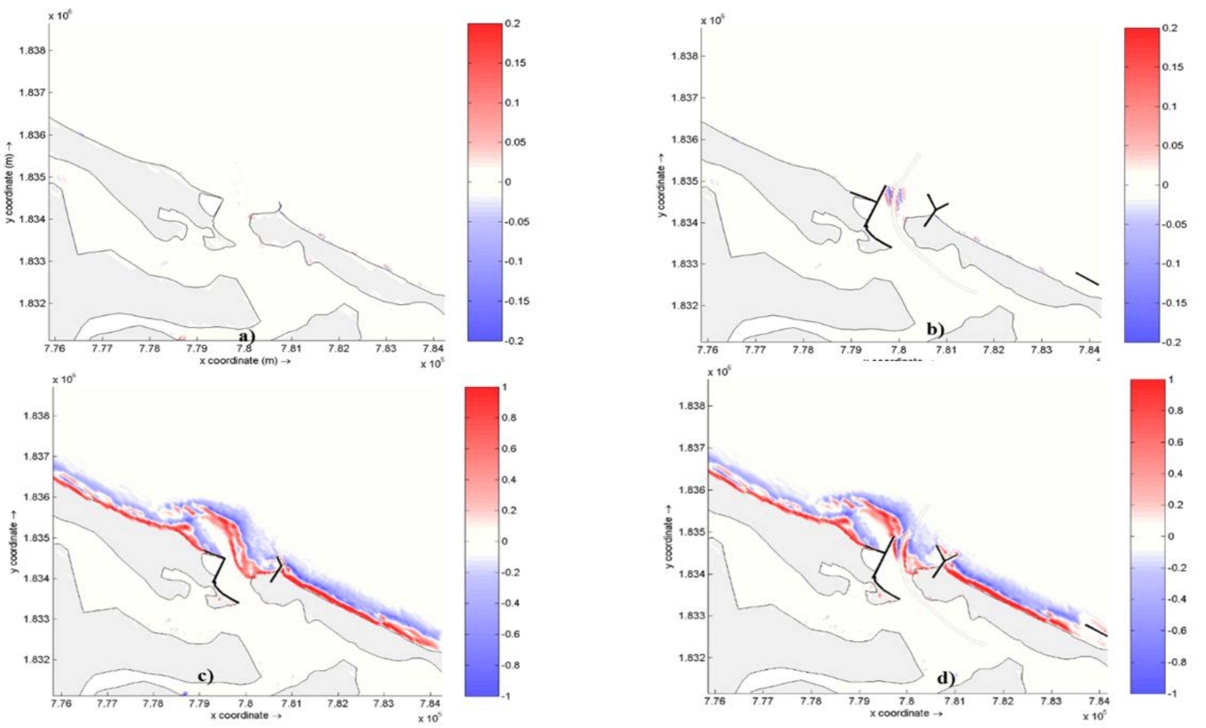

**Figure 7.** Change of seabed during the southwest period in the conditions of existing PA0 (a), structure PACT (b) and during the northeast period in the conditions of existing PA0 (c) and structure PACT (d).

### 3.6. Drainage the Frequency 2% Flood

The flood drainage for SC3 with flood frequency of 2% are shown in Table 2. Water level and velocity are extracted at 12 locations along the river from Thao Long bridge to Thuan An estuary (Figure 8). The water level along the river is higher in the proposed structure scenarios than the water level in the existing condition. The maximum water level difference is at the estuary throat locations T7, T8, T9 (Figure 8) by 16 cm. The increasing water level is from 10-12cm at locations T4, T5, T6, these locations are in lagoon area upstream of estuary throat. The water levels are not increased at locations in river and sea, ie. T1, T2, T3 and T11, T12. This means that the elongation of jetties has no effect to these locations. Flow velocity is changed with different trends along the estuary. Flow velocity is increased at locations T10, T11, T12 about 40 cm/s to 94 cm/s due to shrinking of width of estuary and are decreased at the rest locations (less than 18 cm/s) at throat of estuary due to the obstruction of higher water level. The increasing of velocity has promoting effect to dispose of sedimentation of the estuary channel meanwhile increasing water level at estuary locations is not much to threaten the bank of estuary.


**Figure 8.** Sketch map of 12 locations with the conditions of existing and elongated jetties.

**Table 2**. A comparison of hydrodynamics between the conditions of existing and elongated jetties under the 2% river flood frequency.

| Locations | Water level (m) | | | Flow velocity (m/s) | | |
|---|---|---|---|---|---|---|
| | PA0 | PACT | Different with PA0 | PA0 | PACT | Different with PA0 |
| 1 | 1.67 | 1.67 | 0 | 1.55 | 1.55 | 0 |
| 2 | 1.24 | 1.24 | 0 | 1.84 | 1.84 | -0.01 |
| 3 | 0.84 | 0.89 | 0.04 | 1.57 | 1.52 | -0.05 |
| 4 | 0.42 | 0.52 | 0.1 | 1.22 | 1.16 | -0.05 |
| 5 | 0.32 | 0.44 | 0.11 | 0.79 | 0.75 | -0.05 |
| 6 | 0.23 | 0.34 | 0.12 | 1.12 | 0.97 | -0.15 |
| 7 | 0.05 | 0.21 | 0.16 | 1.29 | 1.11 | -0.18 |
| 8 | 0.06 | 0.21 | 0.16 | 0.87 | 0.79 | -0.08 |
| 9 | -0.01 | 0.15 | 0.16 | 1.15 | 1.11 | -0.03 |
| 10 | -0.09 | -0.05 | 0.05 | 0.88 | 1.82 | 0.94 |
| 11 | -0.09 | -0.09 | 0 | 0.37 | 1.09 | 0.72 |
| 12 | -0.09 | -0.09 | 0 | 0.3 | 0.7 | 0.4 |

## 4. Conclusions

Thuan An estuary is characterized by seasonal fluctuations of waterways channel and coastal beach. This estuary is wave-dominated lowland coasts. The coastal barrier is built from sand transported along the coast by wave-driven longshore sand transport. In the northeast monsoon season, river flow is small, tidal currents combine with longshore currents by waves to form strong longshore current with direction from northeast to southwest. In the southwest monsoon season the sand bar from the south side will expand to the north, causing sedimentation at the channel of the river mouth.

The study proposes the elongation of 2 jetties to mitigate the sedimentation at Thuan An estuary for enhancing flood drainage and maintain waterway navigation. On the basis of calculated hydrodynamic characteristics for this proposal, it is observed that the flood drainage insignificantly affected by the proposed measure. Although the maximum water level increased at throat channel of the estuary is 16cm but the water level at other location in the river is not changed. A further study is, however needed to improve the result by investigating deeper into the sediment transport regime for whole year and longer period. The structures layout and the size of structures are also need to investigate to find an optimization of these parameters.

The proposed structure measure has a good effect on reducing sedimentation at estuary channel in both southwest and northeast monsoon seasons through morphological modelling results. This proved the efficiency of the proposed elongation of 2 jetties structure event out this structure caused a little higher water level at some location in the estuary channel.

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