STUDY ABOUT COASTAL EROSION IN TIEN GIANG PROVINCE, VIETNAM WITH NUMERICAL SIMULATION

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ABSTRACT

Coastal erosions are investigated at Go Cong- Tien Giang province based on field data and numerical simulation to identify causes of coastal erosion and to propose a suitable countermeasure. Results obtained from data analysis suggest that degradation of coast line takes place at an amount of 9.4 m in annual maximum and such a coastal erosion may be caused mainly by north-east monsoon. A numerical model is proposed for evaluating coastal currents and associated coastal changes. However, wind – induced currents cannot be included properly yet in the model. The results obtained from numerical simulation suggest that currents resulted from tidal waves and river flows are not large enough for carrying sediment from bank areas. Therefore, the flow patterns and strengths are investigated numerically without sediment transportation. According to the results, tidal currents are influenced by river flow discharge and these are weaken by constructing a dike along the coast.

Keywords: Mekong Delta, Go Cong Tien Giang, coastal erosion, sediment transportation.

INTRODUCTION

Go Cong Dong is a rural district of Tien Giang province in the Mekong River. Mekong River which is one of the largest rivers in the world flows through Laos, Myanmar, Thailand and Cambodia, starting from China, and pouring into the East Sea of Vietnam. Figure 1 shows the study area ranging from the Soai Rap mouth to Cua Tieu mouth implemented by the iRIC model. This region is not only the gateways to the East Sea, but also a place with favorable conditions for local and international trade. Coastline in this study area is very complicated with many different changing shapes observed in the 30 years period from 1985 to 2015. Sea dykes and coastal mangrove play crucial role in maintaining the safety of lives and property for nearly 150.000 native residences in this area. However, the coast of Go Cong Dong spreads from north to south, so annual adverse impact of large waves is due to the Northeast wind, resulting in active shoreline erosion. In addition, Vietnam is one of five nations hardest hit by the climate change and rising sea levels in the world (World Bank, 2011).

This study aims to understand the situation of coastal erosion in study area and to investigate the cause of erosion and proposes the countermeasure against the coastal erosion in Go Cong – Tien Giang province.

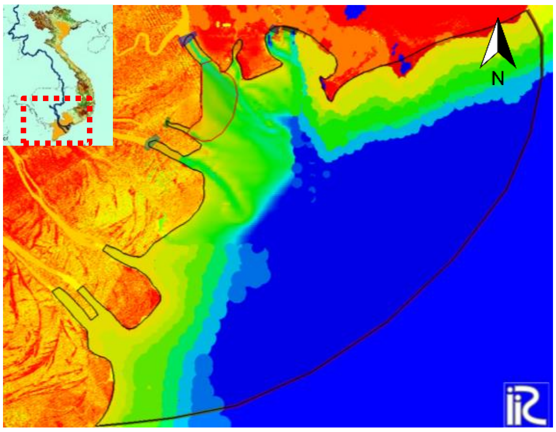

Figure 1: Coastline from the Soai Rap mouth to Cua Tieu mouth

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METHODOLOGY

To investigate coastal changes in the study area, satellite image data are employed. Coast line changes are identified by comparing the image data which were accumulated for long years. Then to evaluate such coastal erosions, a numerical model called Mflow_02, one of the module of iRIC solvers, which is composed of depth integrated flow model and sediment transport model, is used to simulate the coastal currents and erosion. A finite element method that uses triangle element is employed in order to solve the governing equations numerically. Figure 2 shows the study area reproduced by means of triangle elements. Grid size with specify maximum area for cell is 10,000,000 m². Particularly grid size in refinement region is smaller mesh than grid size of the whole area.

Only tidal motions and river flows are taken into consideration to calculate the coastal changes of study area. Wind induced currents are not included in computations. Figure 2 shows a cross sectional A-A' within 13 points along the study area implemented in the iRIC mode, then the computed bed profiles are investigated.

Table 1 shows calibrated parameters to set up the model. Figure 3 shows the locations at which the boundary conditions are specified for the flow discharges and tidal waves and the initial conditions are specified for starting computation.

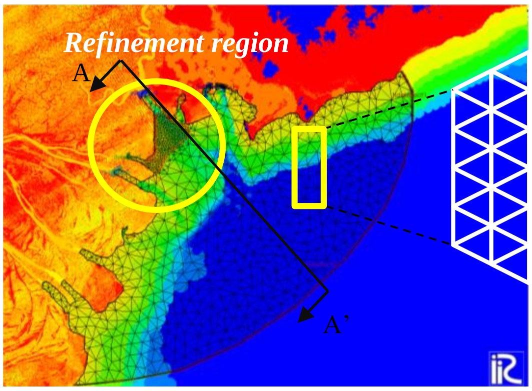


Figure 2: The mesh of the study area implemented in the iRIC model

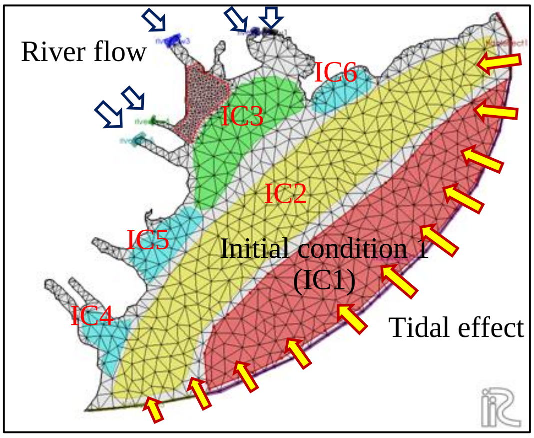


Figure 3: Initial conditions

DATA

Topography data of this target study area are obtained from observed survey in State level by the project "Research on hydrodynamics estuaries affected by sea dyke in Vung Tau – Go Cong" in 2012 by Southern Institute of Water Resources Research (SIWRR), which is illustrated in Figure 2. The Shuttle Data Topography Mission (SRTM) are obtained from the elevation database of Earth. In the study area, the maximum elevation value is 5m and the minimum is -25m. Waves, winds, grain size of sediment transportation and river flow discharge data are collected from the SIWRR, Vietnam. To analyze the effect of the tides on the coastline, this research use the data on the tidal variation which was provided by Japan Meteorology Agency. The data were collected on Ishigaki, which located in southern of Japan.

Table 1: Calibrated parameters

Category	Characteristics
1. Duration	648000 sec
2.Computation time step	1 sec
3. Manning roughness	0.03
4. Grain size	observed data
5. Boundary condition	river flow, tidal effect
6. Initial condition	water surface

RESULTS AND DISSCUSSION

Estimated coastal changes

For understanding the changes on the shape of the coastline, the simulated coastal areas derived from satellite imagery. The shoreline was estimated and compared to the reference of the year 1985.

Thus, we can understand the gain or loss of area, the rate of change, and identify the most affected areas. The time interval of the analysis is five years and the data ranges are from 1990 to 2015. Figure 4 shows erosion and deposition rates along the coast of Go Cong – Tien Giang province. The results show the deposition only appear in the period from 1985 to 1995. From 1995 to 2015, the erosion takes place, and most serious erosion occurred in the period from 1990 to 1995.

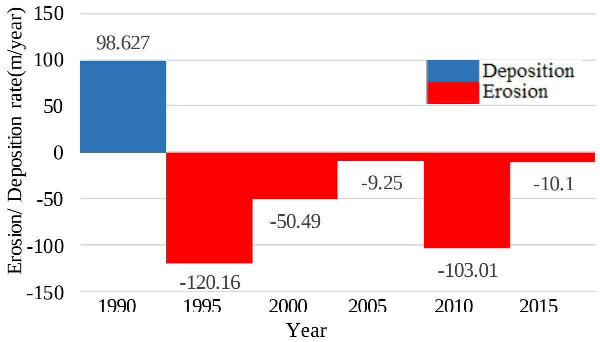


Figure 4: Erosion/Deposition rate in Go Cong Dong from 1985 to 2015

From the output of simulation by Mflow_02 Model, estimated temporal changes of bed profiles along the line A-A'. However, the temporal changes of bed profiles could not be properly identified. For investigating the bed evaluation change, the results are illustrated in Figure 5, which shows deviations of the bed elevation from the initial bed elevation.

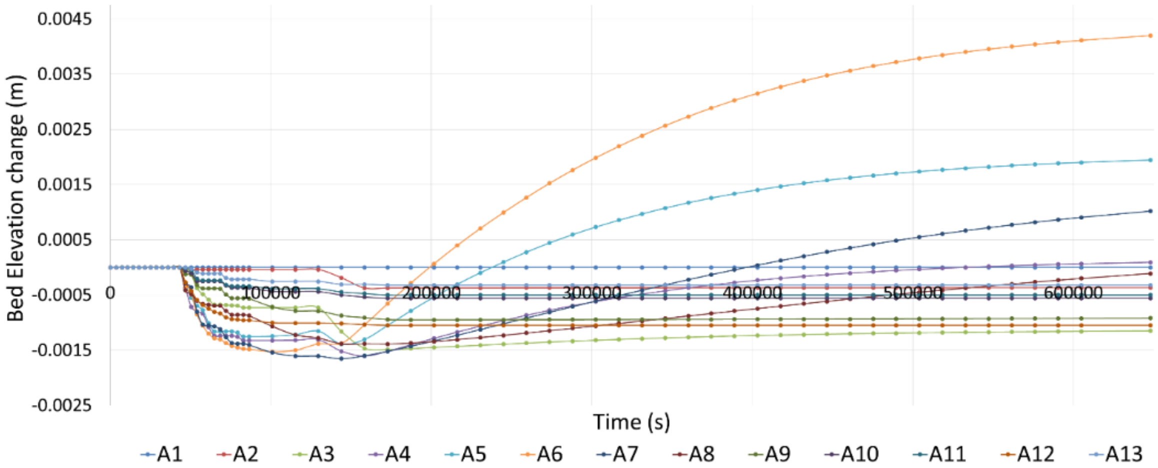


Figure 5: Bed elevation change of 13 points from cross section A-A'

Flow Pattern

According to the computed results on coastal erosion, there were not representative coastal changes in present computational conditions. Therefore, we take a look at flow patterns produced by tidal motions and river flows. Computations are conducted in the condition of tidal motion without river flow in Case 1 as well as in the condition of tidal motion with river flow in Case 2. Figure 6 shows the tidal motion employed in computations of the flow patterns and specified timings for investing the flow pattern.

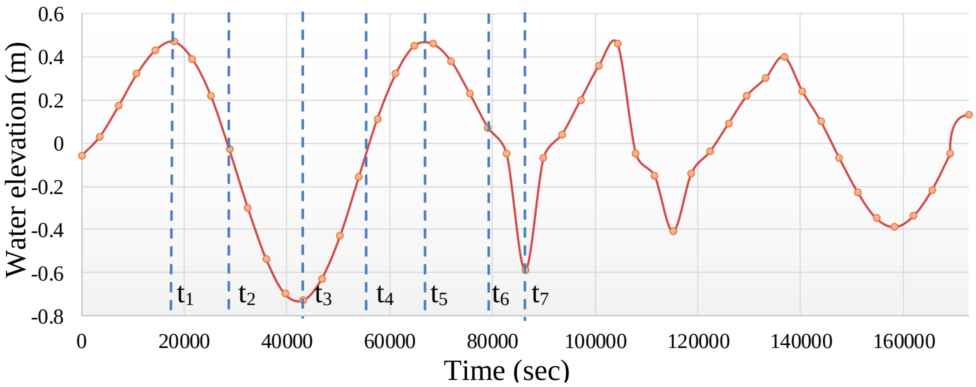
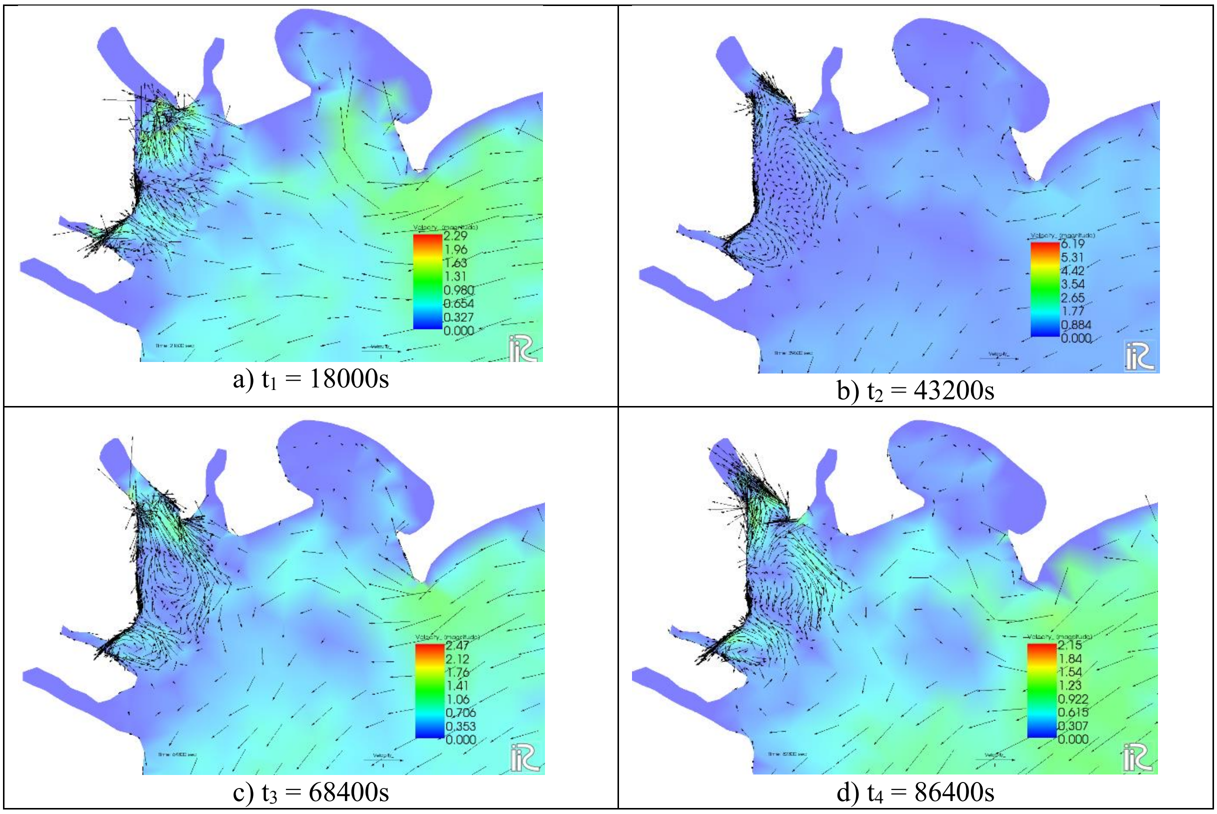


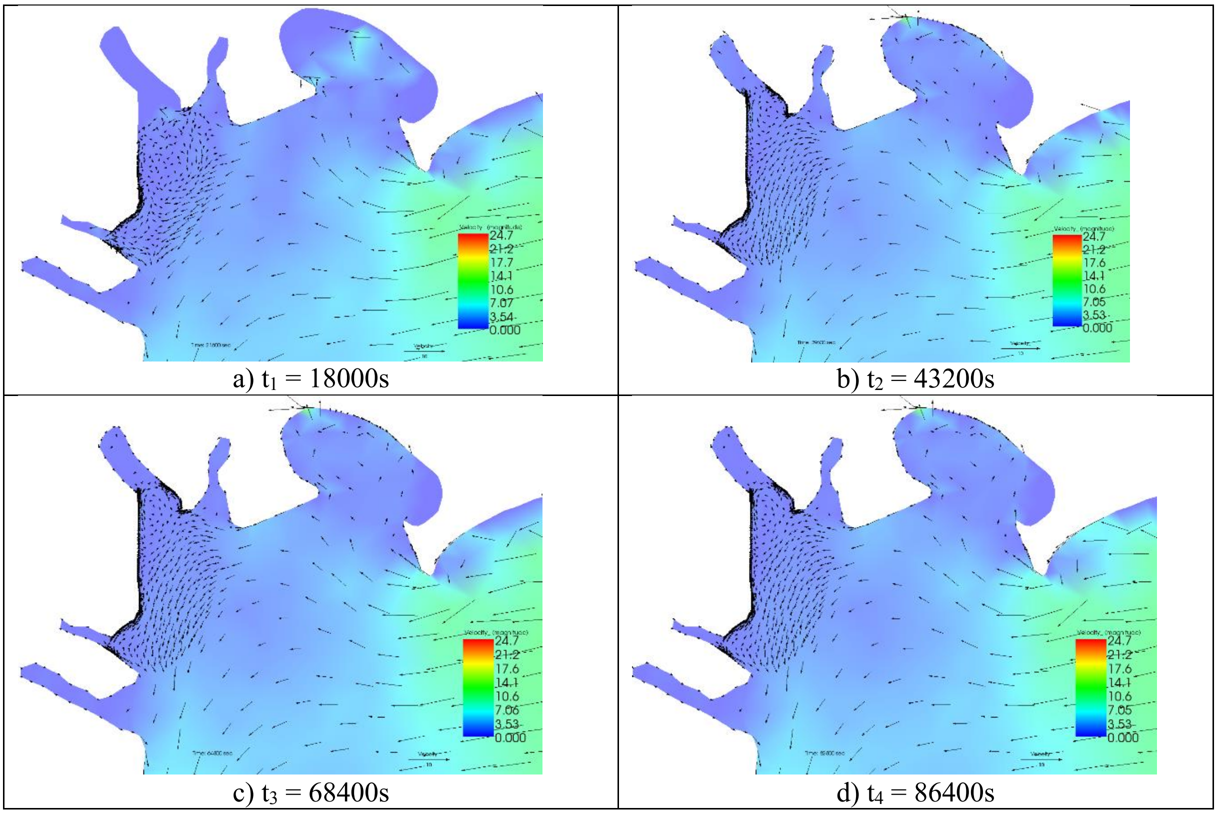
Figure 6: Tidal motion and specified timings for investing the flow pattern

Figures 7 and 8 show the flow patterns computed at each timing in case 1 and case 2; the results suggest that flows without no river flow discharges are strengthened in the coastal region.



a) t_1 = 18000s
b) t_2 = 43200s
c) t_3 = 68400s
d) t_4 = 86400s

Figure 7: Magnitude and dimension of velocity in case of simulation with assigning tidal and wind effect as boundary condition (no river flow discharge) (Case 1)



a) t_1 = 18000s
b) t_2 = 43200s
c) t_3 = 68400s
d) t_4 = 86400s

Figure 8: Magnitude and dimension of velocity in case of simulation with assigning tidal, wind effect, river flow discharge as boundary condition (Case 2).

These pictures show magnitudes of velocities in semidiurnal tidal cycle that includes two high and two low tides of approximately equal size in lunar day. However, depending on tidal period, when the magnitude of tide is 0m, highest tide value, or lowest tide value, this study can find out, which tide is worse effected in target area. In case without river flow discharge, numerical simulation shows the highest effect at the high tide (Figure 7). In case consider effect of river flow discharge, after 43200 sec (12 hours) the dimension of velocity is not changed much (Figure 8).

The results obtained from the computations on coastal changes suggest that the coastal change and corresponding sediment transportation do not take place because the currents produced by river flow and tidal motion are weak to transport coastal sediment. This may suggest that the coastal erosion is caused by wind waves and wind – induced currents. The flow patterns are investigated numerically for two cases: influences of tidal motion – Case 1, tidal and river flow – Case 2. The difference of flow patterns is not notable in the results obtained from Case 1 and Case 2. However, the flow patterns resulted from the tidal motion and the flood flow are strengthen, which are characterized by a large eddy. In order to discuss coastal erosions, we need to evaluate the influences of wind waves and wind – induced currents which is worthwhile to be investigated as a next step.

In case 3, an influence of a river flood as boundary condition is considered, the flow discharge is illustrated in Figure 9. Figure 10 shows the flow patterns which are computed at the first point (Figure 10a, before flooding happen), second point (Figure 10b) and third point (Figure 10c) during the flooding. The result shows that the currents become strong during flood, and the large eddy is formed at point 3.

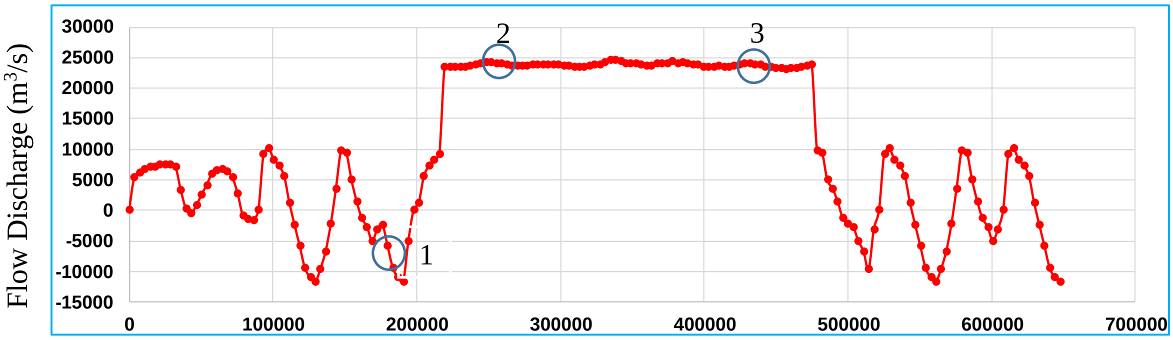


Figure 9: River flow discharge data including flood discharge scenario simulation

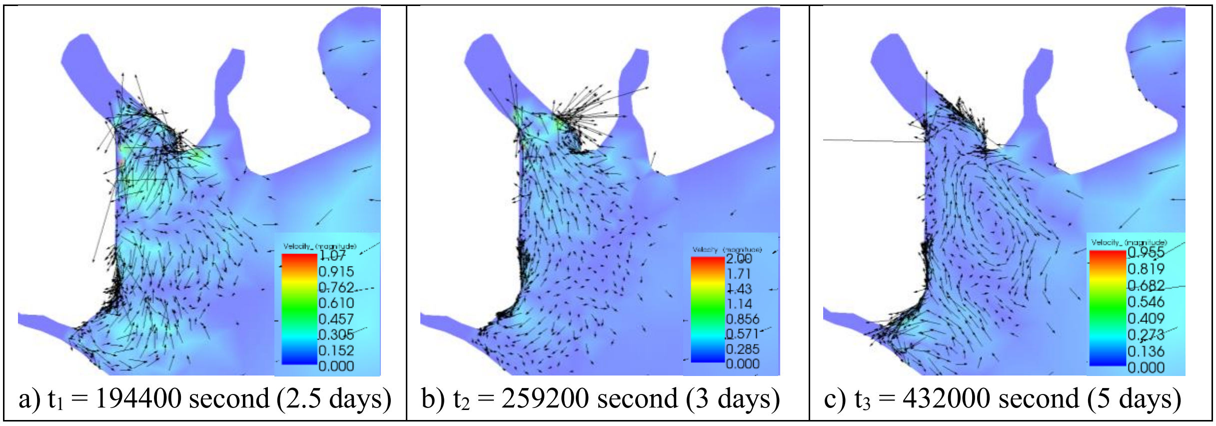
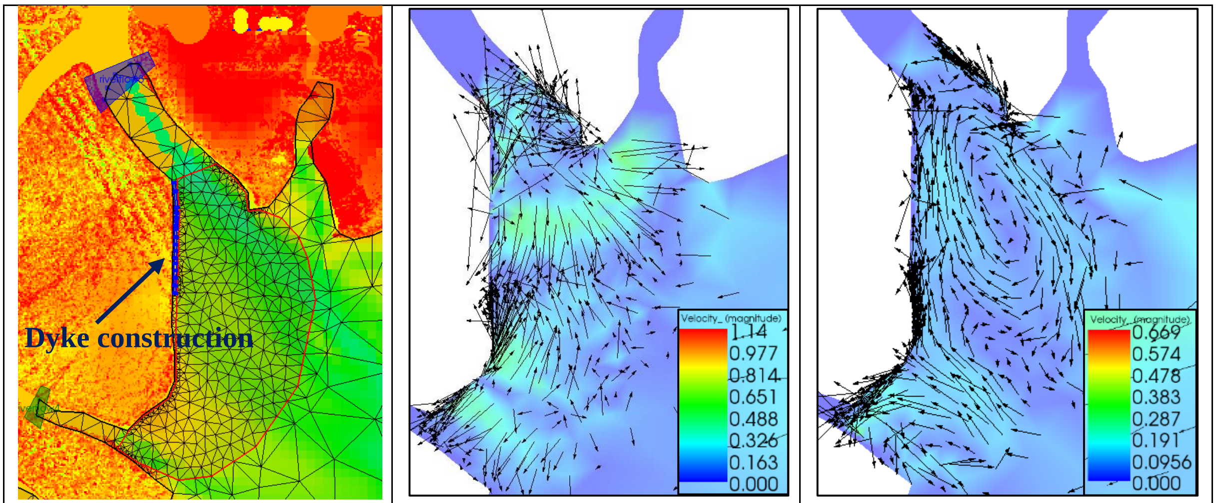


Figure 10: Magnitude of velocity in case of flood discharge as boundary condition (Case 3).

In case 4, dyke construction for protecting coastal against erosion, which is set up to simulation by Mflow_02 model. Figure 11a shows suggestion the countermeasure by means of a dyke construction. Flow patterns computed before dyke construction shown in Figure 11b and after applied countermeasure shown in Figure 11c. The magnitude of flow velocity is reduced by 58.68% after the dyke constructed, it is a huge change and can reduce erosion and increase sedimentation.



a) Countermeasure by means of a dyke construction | b) Flow patterns computed before dyke construction | c) Flow patterns computed after dyke construction

Figure 11: Countermeasure by means of a dyke construction (Case 4).

CONCLUSION

The present study discusses the coastal erosions in study area based on the field data as well as numerical simulations. Coastal erosions are estimated as 9.44 m per year in maximum, 1.64 m per year in average and 0.02 m per year in minimum. Coastal erosions may take place due to natural phenomena such as storm surge in addition to impacts of human activities such as deforesting of the mangrove, construction of canals. Numerical simulations are conducted to investigate the causes of the coastal erosion. The results suggest that the tidal waves and normal river flows are not main cause for coastal erosion, but wind waves and wind – induced currents may cause mainly the coastal erosion. Flow patterns are investigated numerically in relation to coastal erosion. According to the results, the flood discharge changes the flow pattern and flow strength remarkably in the coastal region. The construction of dyke changes the flow patterns, resulting in representative decrease of the flow strength. There are many unsolved problems in present study. Specially, wind waves and wind – induced currents, which may be main causes of coastal erosions, are not included in present numerical model. We have to develop a numerical model suitable for predicting coastal erosion of the study area. Although we proposed several countermeasures, we do not evaluate an effect of each countermeasure. In conducting the proposed measures, we have to test their validities, which need further research.

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