Monitoring & Simulation Assessment for Coastal Reclamation Area Using Remote Sensing Approach

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ABSTRACT: In this research, the operation of physical oceanographic processes in the coastal reclamation and the types of interaction between these processes with marine and the terrestrial will be examined. Most of these changes are mainly due to a very diverse with complex natural process and also human activities by modifying, disturbing the coasts both directly and indirectly. These changes can be quantified through an assessment of coastal dynamics simulation and information obtained from this study is very important and very useful in the prediction of coastal responses to human interferences. Placing fill in a reclamation area may affect the dynamics of the adjacent sea as well as threatening the coastline movement due to erosion, deposition and connecting lagoons for coastal zone management. Very dynamic coastlines, such as sections of Straits of Johor coast along Iskandar Development Region (IDR), pose considerable hazards to human use and development, and rapid, replicable techniques are required to update coastline map of these areas. This research theme consists of studies in the relatively shallow coastal zone using 3D simulation computation and theoretical modeling. Delft3D-FLOW is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a rectilinear or a curvilinear, boundary fitted grid. In 3D simulations, the vertical grid is defined following the sigma co-ordinate approach. The hydrodynamic conditions (velocities, water elevations, density) by short wave propagation calculated in the module for performing coastline tidal analysis of generated time series. In addition, process models for breaking waves, momentum mixing due to the interaction of long shore and cross-shore vertical mean profiles, and bottom shear stress enhanced by observations of both wave models are considered to detect and quantify coastal modification in future.

1. Introduction

Reclamation can be defined as a process of land reclamation to create new land near the sea or riverbeds. In general, land reclamation is an activity that involves filling a sea or coastal area with fill material such as stone, sand and soil in order to obtain the new land. In the last decade or more, there was an increase in the number of coastal land reclamation projects for residential, commercial and industrial cities in the developed coastal reclamation project in Malaysia. The success of any coastal reclamation is highly dependent on sound planning and design practices, which includes both engineering and non-engineering aspects. The recent advances in mathematical modeling and simulation have contributed to the increase in

the practices of planning and design for the project and the evaluation and quantification of environmental impacts of potential short-term or long-term decision.

Iskandar Development Region (IDR) is an initiative by the Malaysian government to make the region as significant of development of industrial, logistics, tourism and business center of the larger urban conurbation with a broader economic base and by 2030 which is projected to have per capita income of developed countries. IDR officially launched by the Fifth Malaysian Prime Minister Abdullah Ahmad Badawi in November 2006.The 2216-sq-km IDR is located in the southern Johor state of Malaysia.

Satellite Remote Sensing due to its repetitive, multi-spectral and synoptic nature provides a unique view to recognize various features on land and sea. This technique can be of great help in collection of continuous wave currents, wind, tides, suspended matter, shallow water area, wetlands, mangroves, mudflats and other coastal feature and coastal changes, like land accretion or erosion. Thus, a study has been undertaken to monitor coastlines changes along the coast of Straits of Johor along Iskandar Development Region (IDR) using multi-temporal with panchromatic satellite imagery, SPOT 5 in achieving the detailed characteristics of underwater terrain. The multi-spectral image of SPOT-5 has the ability to inverse water depth, and its high resolution can describe more detail topographic information under water. These data were processed using interactive digital image processing and enhancement techniques like color enhancement, Principal Component Analysis (PCA).Delft 3d can achieve numerical modeling of current flows, sediment transport, waves, morphological developments and ecology.Delft3D operates by means of exchange between the average vertical 2D mode and 3D just by changing the number of layers. These features allow establishing and investigating the behavior of the model in 2D mode before going into full 3D simulations. The flows caused by tides, wind, and density gradients, and the induced waves propagating a current that directionally spreads more short waves over irregularities bathymetries which is including the current-wave interaction based on the shape of the land reclamation area.

2. Objectives

The aim of this study was to simulate the wave flow propagation reclamation response & shore face assessment of coastal area. Demonstrate that significant of physical process responsible erosion & deposition prediction before and after reclamation. Investigate the dynamic of seabed topography in shallow coastal water.

3. Study Area

Study area is located in south-central part of Iskandar Malaysia, Danga Bay and Tambak Johor which is the first and largest mixed Johor Bahru commercial housing development. The biggest reclamation starts along the 25km beach overlooking the Straits of Johor, and covers about 450 acres. The area is vulnerable to erosion and deposition as a result of the narrow straits area and the limits of flow wave current which is had fast flood experience issues after the reclamation started.

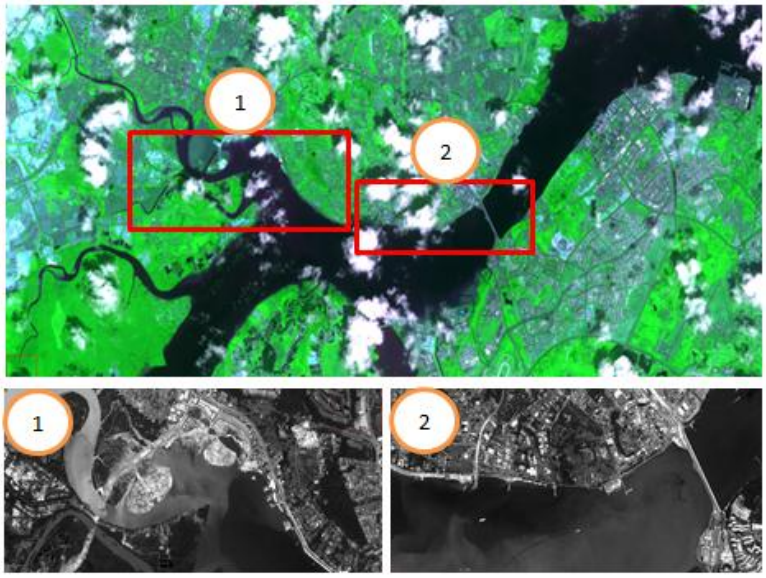

Figure 1: Study Area, Straits of Johor; 1.Danga Bay 2.Tambak Johor nearby Johor Bahru city

4. Significant of Study

Some areas of the state located in low-lying areas, especially near the coast is likely to inundate the sea during the next nine years the phenomenon of sea level rise due to global warming. Analyzed Department of Water and Environment, Dr Tan Lai Wai, found that since 2004 until earlier this year, sea level has risen an average 10 centimeters (cm) per year. This was affected to the Kampung Skudai Kiri and Kampung Pasir was among the earliest settlements everyday by fast flood issues since the reclamation construction was started. These places are known as the earliest settlements and economic activity centre here, but that distinction is not reflected today. Since July 2010 the extraordinary rainfall identified as among the main causes of the flashfloods that hit the Johor Bahru city influence by the reclamation area nearby. That the high tide levels caused the river's water level at the time of the flood was registered at 3 meters above mean sea level said by Head of Strategic Communication, IRDA. A hydrology study in 2002, commissioned by Gerbang Perdana, builder of the scrapped bridge to replace the Causeway, found Johor Straits to be heavily polluted with heavy metals, sewage and leachate. The pollutants, accumulated over the years, were trapped on both sides of the causeway. In addition, this strait reclaimed water flow of certain rivers Sungai Chat and Sungai Segget will be smaller, and people close to worry about flash floods more likely to occur since the reclamation started. So,the reclamation construction will open the flow for Selat Tebrau at the Tambak Johor to avoid this problem which is influence the erosion and deposition exposed to the coastal reclamation area later.

Figure 2: Water flow improvement plan at existing causeway nearby Johor Bahru city
(Sources: Iskandar Development Region / The Coastal Zone Part 1)

5. Data & Methodology

SPOT 5 sensors with panchromatic image data will at 2.5 meters and 5 meters nominal pixel sizes and multispectral image data at 10 and 20 meters nominal pixel sizes. Multispectral image data are collected in 3 bands with a 10 meters nominal pixel size and a 4 bandwidth a 20 meters nominal pixel size. Bands 1, 2 and 3 are visible green, visible red and near infrared respectively. Band 4 is a short-wave infrared band. The data was taken by two previous year 2009 and 2010.The latest bathymetry data was taken from Malaysian Marine Department and processing of SPOT 5 inversion water depth imagery with single and dual band method.DEM Digital Elevation Models are data files that contain the elevation of the terrain over a specified area, usually at a fixed grid interval archeived from orthorectification of SPOT 5 (5-10m resolution stereo scene extracted.

5.1 Geometric correction & orthorectification

Geometric correction done with both primary satellite image and master plan image that to ensure the image in the same position on strictly correspond use the ground control points measured. The corrected image and the corrected master plan image are well-matched at the same location with the same geographic coordinate system of WGS84.GCPs are collected for both (i.e. 2.5 meters or 5 meters panchromatic band and 10 meters band 3, 2 and 1 color composite). Sufficient GCPs SPOT scene is collected for use as control in the orthorectification transformation (a minimum of 12 for a full scene).

Figure 3: 1: Danga Bay master plan; 2: Danga Bay existing land use; 3: Danga Bay purposed land use after reclamation *(Sources: Planning and Implementation, Part 3 Physical Planning Initiatives; Iskandar Development Region 2009)*

5.2 Image Enhancement & Overlapping

Image enhancement proceeds for improving feature interpretability through various techniques, such as adjusting brightness and contrast. By optimize gray level balancing of the panchromatic bands and color balancing of multispectral bands between adjacent scenes while maintaining the variability in the source data (saturation should be avoided).After that the master plan image were overlapped to real image to determine the reclamation area which is cover over the sea.

Figure 4: The overlapping image between reclamation master plan with satellite imagery image.

5.3 Depth Inversion

The coefficients of single-band model and dual-band model are respectively calculated based on the selected controls. SPOT-5 only has two visible bands of green and red, and preferred being use the first of these two methods only which is the single-band model while the red-band model is better than the green-band model. (Shanwei Liu, Jie Zhang, Yi Ma, 2007).Additional, the dual-band model is the best of all the models used, its mean relative error is 22%, and its mean square error is 1.87m. The model worked relatively well for the shallow water. (Shanwei Liu, Jie Zhang, Yi Ma, 2007).

5.4 Simulation with Delft-3D

Delft3D-FLOW is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a rectilinear or a curvilinear, boundary fitted grid. In 3D simulations, the vertical grid is defined following the sigma co-ordinate approach. The hydrodynamic conditions (velocities, water elevations, density) by short wave propagation calculated in the module for performing coastline tidal analysis of generated time series. In addition, process models for breaking waves, momentum mixing due to the interaction of long shore and cross-shore vertical mean profiles, and bottom shear stress enhanced by observations of both wave models are considered to detect and quantify coastal modification in future.

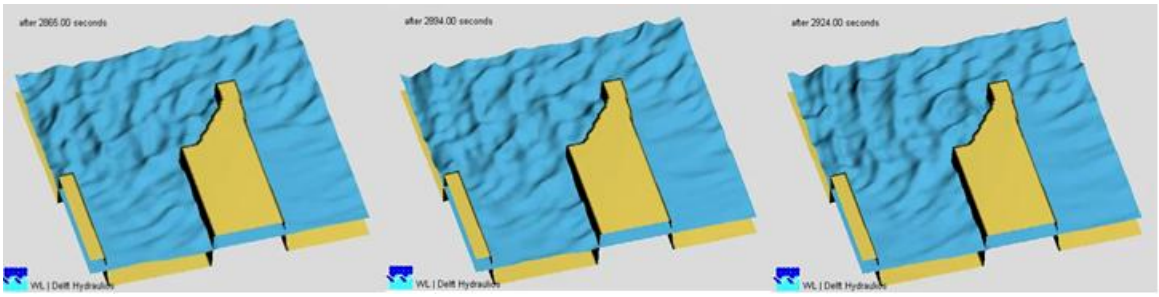

Figure 5: Simulation of the sample wave flow of coastal reclamation *(Sources: Deltares)*

5. Discussion

Danga Bay is the position at the Skudai river embankments which will unveil the impending erosion and deposition on the formation of the delta estuary within short and long term changes. In addition, with the proposed plan of the flow opening at the causeway of Johor Straits is still in a statistical. This will be

affecting the changes at the reclamation area indirectly. Using Delft-3D FLOW, the erosion effects can be earlier detected on the basis of sea depth and current speed in certain location of the study area. Restructuring the breaking waves can be made and proposed in the coastal area. The simulation will be implementing on wave breakers in the sea which is not included in the original master plan for the purposes of reclamation calm current conditions in the area of sea waves and shaped the current leaving at estuary of river Skudai.

The simulation at the estuary and the coastal will also be designed with different conditions such as tidal conditions at coastal; the rise of sea level due to changes in extreme weather such as rain and wind speed factors that could influence the flow current speed at the coastal area. This was made in order to avoid the phenomenon of flash floods in the reclamation area and at the surrounding area. The result will be presented in the form of animated simulations and the arrangements of data that are expected to change before and after reclamation were completed.

6.References

Bathymetric Ability of SPOT-5 Multi-spectral Image in Shallow Coastal Water-Shanwei Liu, Jie Zhang,Yi Ma ,Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, Yantai, China (2007).

Coastal engineering Research Center, Department of the Army, Waterways Experiment Station, 1984."Shore protection manual".

Delft3D;Functional Specifications;Version: 2.20 April 13, 2010 Copyright c 2010 Deltares.

Delft3D-FLOW-Simulation of multi-dimensional hydrodynamic flows and transport phenomena,including sediments; User Manual-Part of Hydro-Morphodynamics ,Version: 3.15; 14 April 2011 Copyright c 2010 Deltares.

Delft3D-WAVE; Simulation of short-crested waves with SWAN; User Manual;Version: 3.04,January 12, 2011 Copyright c 2010 Deltares.

Dhakal, A.S., Amada, T., Aniya, M., Sharma, R.R., 2002. Detection of areas associated with flood and erosion caused by a heavy rainfall using multitemporal Landsat TM data. Photogrammetric Engineering and Remote Sensing 68 (3), 233–239.

Iskandar Waterfront Development , Iskandar Development Region, 2009.

Nittrouer, C., Brunskill, G. J., Figueirado, A. G., 1995, Importance of tropical coastal environments. Geo-Marine Letters, 15: 121-126.

Section B Planning and Implementation; Part 3 Physical Planning Initiatives (CHAPTER 12).The Coastal Zone; Iskandar Development Region (2005).

SPOT 5 Orthorectification and Processing; Specifications and Guidelines,Version 2.0 (January 16, 2006) Forest Services, British Columbia.

Three-dimensional model of flooding ofthe river floodplain - visualization of ecohydrological interactions; Daniel Kaczorowski, Joanna Sekulska-Nalewajko, Edyta Kiedrzynska MEMSTECH'2006, May 24-27, 2006, Lviv-Polyana, UKRAINE.