STUDY OF THE SEDIMENTATION TREND IN THE PROSPECTIVE AREA OF PORT OF MARINE CENTER, CIREBON BASED ON REMOTE SENSING DATA

by :

Undang Hernawan [1)]

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ABSTRACT

A coastal zone is the interface between the land and water that influenced by both of them. Coastal dynamic is influenced by many factors from land and sea, such as sedimentation and current. In order to support marine facility, Marine Geological Institute (MGI) plan to build a port. The prospective area is behind MGI office at Cirebon. This study use multi temporal remote sensing data in order to observe trend of coastline change around MGI.

Based on the interpretation of the data, there are sedimentation around the MGI water and abrasion due to the presence of Kejawanan's jetty and Kalijaga River. The result also shows that the current in this region is moving from southeast to northwest. The presence of the Kejawanan's jetty stymies the movement of sediment. The sediment which is normally moving to the north of the jetty is then trapped on the south side of the structure, so that the sediment precipitates in this region and makes it as the active region of sedimentation and accretion. The presence mangrove conduces to support sedimentation speed and accretion at this region, because of his function as the catchment area. Abrasion occurs in the eastern part of MGI office at the Kalijaga river mouth within the bay. The Kalijaga River mouth is predicted to be the primary source of sedimentation in this area.

The coastline change caused by sedimentation will be continuing as long as it is supplied by the sediment. The direction of the sedimentation is parallel to the jetty and it forms ellipsoid, with the sedimentation/accretion region is behind MGI office. The abrasion area is found in Kalijaga River mouth and a small area beside Kalijaga River. In order to build a port, we have to consider this sedimentation process. One of the alternatives to build the port is to make a quay pile model which gives way the current to pass through the other side of the port. Another alternative is to build the port as a pond model but it needs accuracy in building the mouth of jetty to minimize the sedimentation process.

Keyword : sedimentation, Cirebon, remote sensing

SARI

Pantai/pesisir merupakan wilayah antara daratan dan lautan yang masih dipengaruhi oleh keduanya. Dinamika pantai dipengaruhi oleh faktor-faktor dari daratan dan lautan seperti sedimentasi dan arus. Untuk menunjang "marine facility center" Puslitbang Geologi Kelautan

1. Marine Geological Institute, Jl. Dr. Junjunan No. 236 Bandung

(P3GL) bermaksud untuk membangun pelabuhan. Daerah yang prospektif adalah di belakang kantor P3GL, Cirebon. Studi ini menggunakan data citra satelit multi temporal, yang berguna untuk melihat arah perkembangan dan perubahan garis pantai di belakang kantor P3GL dan sekitarnya.

Berdasarkan interpretasi data citra, di daerah studi ditemukan adanya daerah akresi/ sedimentasi dan daerah abrasi yang disebabkan oleh adanya dermaga Kejawanan dan adanya sungai Kalijaga. Hasil studi juga menunjukkan arah arus umumnya bergerak dari tenggara menuju barat laut. Keberadaan jetty Kejawanan menyebabkan aliran arus dan sedimen terhenti. Sedimen yang seharusnya bergerak ke arah utama menjadi terhalang dan terjebak di bagian selatan jetty, sehingga mengendap di daerah ini. Keadaan ini menyebabkan daerah ini menjadi daerah sedimentasi yang aktif (akresi). Keberadaan mangrove pada daerah ini juga menambah kecepatan sedimentasi di daerah ini, karena berfungsi sebagai daerah tangkapan sedimen. Abrasi terjadi di sebelah timur P3GL, tepatnya pada daerah lengkungan teluk dan di mulut sungai Kalijaga. Daerah mulut sungai Kalijaga diprediksi sebagai sumber sedimen pada daerah ini.

Perubahan garis pantai yang disebabkan oleh sedimentasi akan terus berlangsung di daerah ini, selama adanya pasokan sedimen. Sedimentasi ini akan berlangsung sampai arahnya sejajar dengan jetty Kejawanan dan akan membentuk ellipsoid, dengan daerah sedimentasi berada di sekitar jetty dan belakang P3GL sementara daerah abrasi berada di sungai Kalijaga dan daerah sebelahnya. Karena itu, pembangunan pelabuhan P3GL sebaiknya memperhatikan kondisi ini. Salah satu alternatifnya adalah dengan membuat pelabuhan model tiang pancang yang memungkinkan arus dan sedimen untuk bergerak ke sisi sebelahnya. Alternatif lain adalah dalam bentuk kolam pelabuhan, tetapi harus tepat memperhatikan mulut pelabuhan untuk meminimalkan sedimentasi yang terjadi.

Kata kunci : sedimentasi, Cirebon, citra satelit

INTRODUCTION

The term "coastal zone" means the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each and in proximity to the coastlines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches.(http://mapping2.../ glossary.html). Coastal dynamic is influenced by many factors from land and sea, such as sedimentation and current. Human activities in the land/upper coarse still can influence to coastal dynamic, such as transporting suspended material to the coast and it is precipitated as sedimentation (Dahuri et al, 2004).

These zones are important because a majority of the world's population inhabit such zones. Coastal zones are continually changing because of the dynamic interaction between the oceans and the land. Waves and winds along the coast are both eroding rock and depositing sediment on a continuous basis, and rates of erosion and deposition vary considerably from day to day along such zones. The energy reaching the coast can become high during storms, and such high energies make coastal zones areas of high vulnerability to natural hazards. (http://www.tulane.edu/~sanelson/ geol204/coastalzones.html)

Marine Geological Institute (MGI) plans to build a port in order to support the marine facilities. One of the factors that influence the jetty is sedimentation on

this area. MGI office is located between Kalijaga River in the southeast that supply sediment and Kejawanan's jetty in the north that changes current direction.

Consequently, stabilization of the coastline is one of the most important considerations when highway facilities are located in the coastal zone. It is also necessary to determine the dominant geomorphic processes of the coastline. This type of information may be obtained from borings, soil surveys, analysis of aerial photographs, and field reconnaissance. Because coastlines may have significant temporal variability, it is necessary to obtain sufficient historical data to identify either this variability or long-term trends. (http:// www.fhwa.dot.gov/.../hec25.cfm)

Remote sensing technology is an accurate technology which record the earth continuously, real time, and up to date, so relatively accurate for describing real condition on the earth and capable to detect environmental changes on long-term trends. One of remote sensing data is Landsat Thematic Mapper (TM) for middle resolution and Quickbird imagery for high resolution. Desiderating of using of remote sensing technology is to describe sedimentation process base on coastal line change on long-term and predict trends of the sedimentation in the next time.

METHOD

The material for this study is Landsat TM imagery that acquired in 1995, 2000 and Quickbird imagery that acquired in March 2002 (rainy season), acquiring June 2002 (dry season) and 2006. The software for data processing is Erdas Imagine, Ermapper and MapInfo.

The method is comparison between multi-temporal imagery that shows environmental changes and its impact to sedimentation and coastal line changes. The interpretation of general current has been done also by analysis of turbidity and suspended material. Landsat TM imagery can show turbidity and suspended material in band 1, 2 and 3 which used in this interpretation.

RESULT AND ANALYSIS

Figure 1 show Quickbird imagery of Cirebon's coastal zone area, exactly behind MGI Office. MGI office located between Kalijaga River in the southeast and Kejawanan Jetty in the north.

A coastline is not static. As waves approach shore and feel the bottom, water piles up and breakers form. Primarily these waves, breaking at an angle to the coastline, are what generate a "longshore current" that parallels to the shore. Importantly, the longshore current is not only moves water in the surf zone, but it is also moves the sediment parallel to the coastline. The longshore current and the resulting transport of sediment is only one of the dynamic processes that constantly alters the coastline. As waves repeatedly hit the shore, water moves onto the beach and then retreats in a continuous cycle. However, the waves are not all that moves on the coastline. In fact, the sediment on the shore is also always on the move. Great energy is expended on the beach as waves crash against the coastline. This energy allows the water to transport sediment. The grains are lifted as the waves in the swash zone move onto the beach, and then the grains are deposited again as the water retreats. As long as the waves hit the coastline straight on (i.e., the wave crests are parallel to the coastline), the sand grains will be picked up and redeposited in the same general area. In this case, no real net movement of sand

Figure 1. Quickbird imagery of the study area

occurs in the swash zone. However, waves generally do not form parallel to the coastline, and thus, usually approach the shore at an angle. Consequently, beach sand will have a net movement up or down the beach, depending on the direction of incoming waves. This net movement of the beach sand is known as "beach drift". (http:// www.earthscape.org/t1/vip01/ vip01c.html). Figure 2 shows a general direction of current base on Landsat TM Imagery.

The direction of the current depends on season, tide condition. Based on the TM imagery, the general direction of current in study area is coming from southeast toward northwest. This TM imagery acquired in dry season. General direction in rainy season is opposite with the dry season, i.e. toward southeast. The average speed is 0,17 m/s. The wave in the study derived from wind data. Wind direction that affected to wave is come from east with average direction 10 – 15 knot. (Novico, 2006) As the waves approach the coast at an angle a current develops which moves parallel to the shore (longshore current). Beach sediments move along with this current

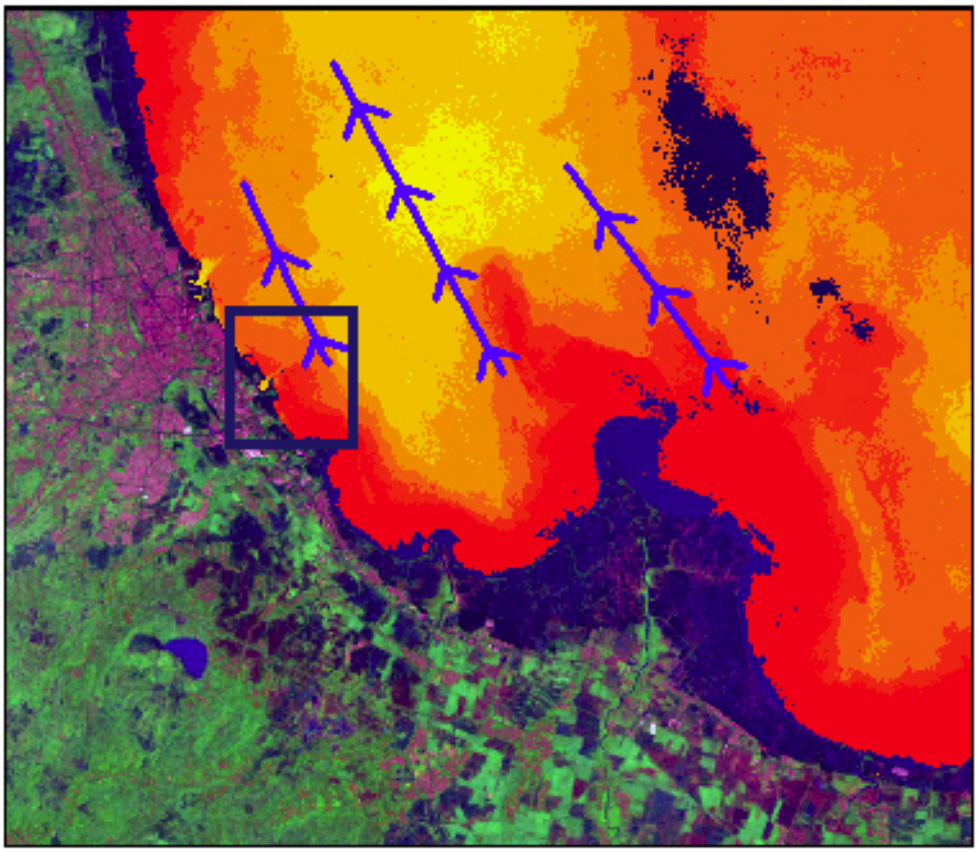

Figure 2. General current of the study area

(longshore drift) (http://physics.uwstout.edu/IntroGeo/shorelines.htm). So, the major effect that influence to the beach is from east-southeast.

The other factor that affect to the coastline is beach structure. Structures such as jetty, piers or groins can alter the normal course of beach drift. Jetties like in the north of MGI office cause wave refraction, and alters the flow of the longshore current, it does cause sediment to be redistributed along the coastline. Sediment is trapped by the breakwater, and the waves become focused on another part of the beach, not protected by the breakwater, where they can cause significant erosion. Similarly, because groins and jetties trap sediment, areas in the downdrift direction are not resupplied with sediment, and beaches become narrower in the downdrift direction. (http://www.tulane.edu/.../coastalzones.htm). Figure 3. shows general structure on the beach and its impact to the sediment movement.

The coastal zone behind MGI office is also influencing by many factors such as existing of Kejawanan's jetty in the north of MGI and Kalijaga River in the southeast of MGI. Figure 4 shows the coastal line change in this area based on imagery data.

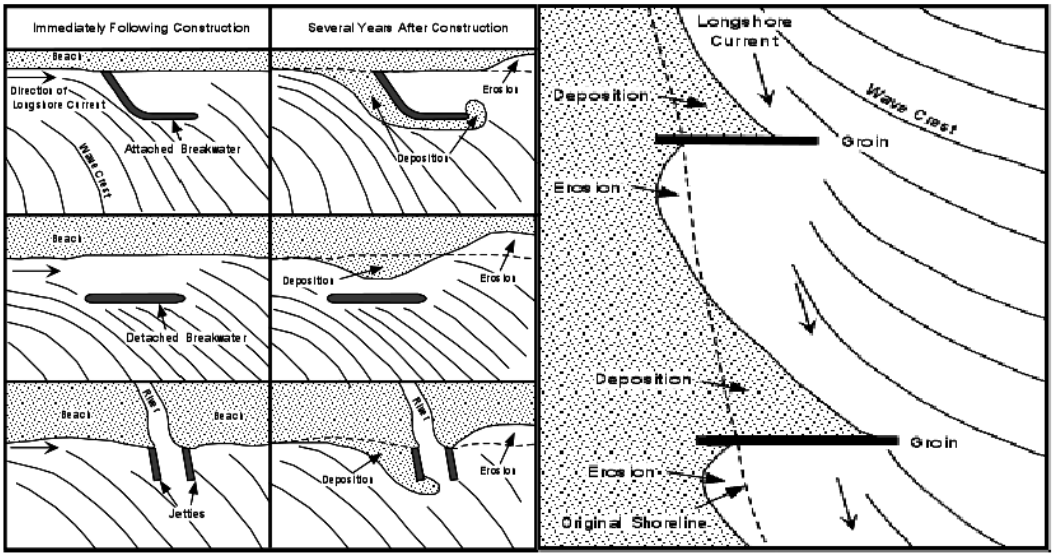

Figure 3. General structure on the beach and its impact to the sediment movement

Generally, the coastal line has moved forward (accretion) along the coast line, except an area in the southeast of MGI beside Kalijaga River. The biggest accretion has been found beside Kejawanan's jetty, i.e. 400 m during 1995 – 2006, that means, the average of sedimentation is 26.3 m/year. The accretion behind MGI has an average of 1.5 – 3.5 m/year. The abrasion area is found in the mouth of Kalijaga River and in a small area at the basin behind Kalijaga River.

The longshore current influences to coastal line changes and sedimentation process, because this current moves the suspended material and precipitates in other area. The direction of longshore transport is directly related to the direction of wave approach and the angle of the wave crest to the shore. The longshore current is the flow of water parallel to the coastline that is driven by the longshore component of the wave-induced thrust as it enters the surf zone. The longshore currents are responsible for the downdrift movement of sediments in the nearshore zone. The longshore sediment transport is influenced by the wave height, period, direction of approach, and the beach slope (AASHTO 2004). The sediment that is carried with the longshore current is called longshore or littoral transport. (http:// www.fhwa.dot.gov/engineering/ hydraulics/hydrology/hec25.cfm)

In this area, current moves from southeast to northwest and take the sediment material from the southeast. Figure 5a shows Quickbird imagery of Kalijaga River mouth in 2002 at the rainy season that supply the sediment material to this area; Figure 5b shows Quickbird imagery 2006 in dry season that shows abrasion in this area.

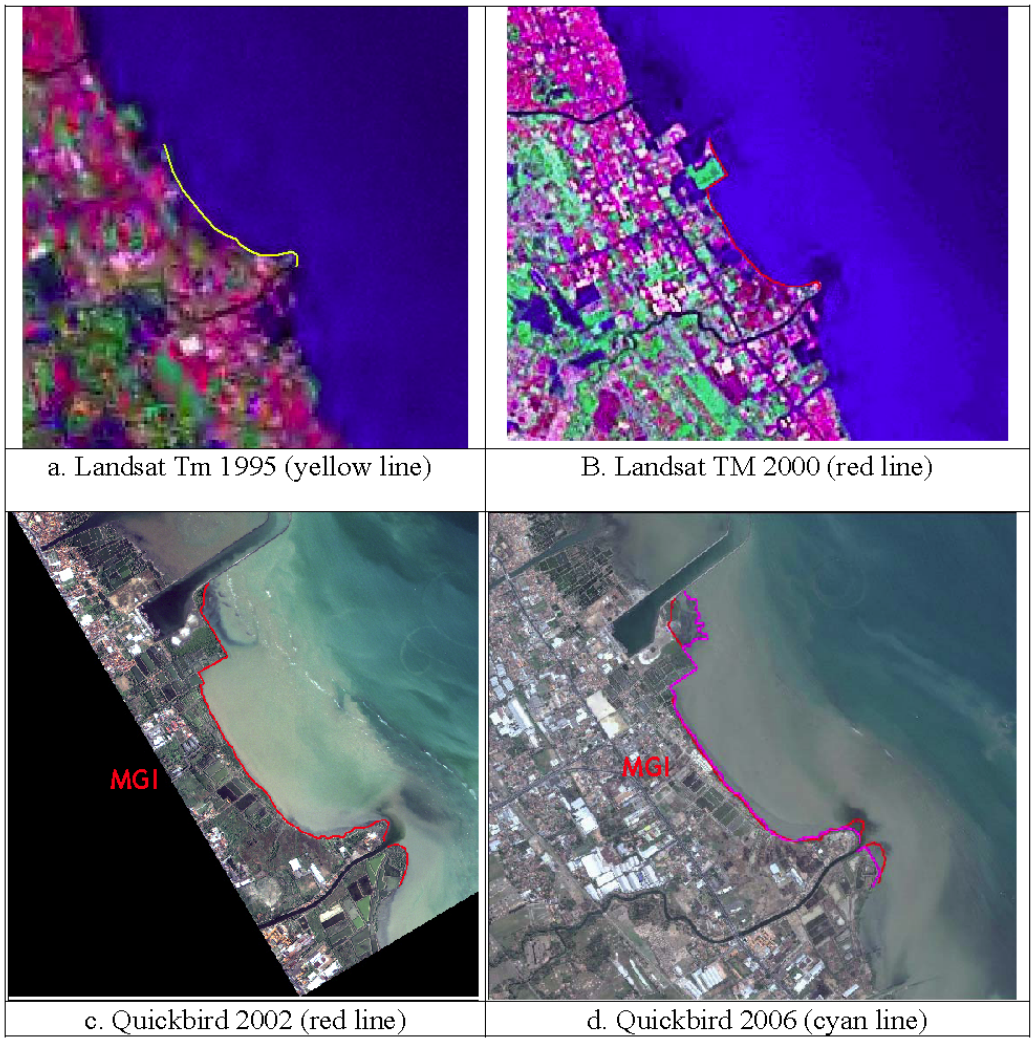

Figure 4. Coastal line change based on imagery from 1995 – 2006
Data source: a,b. Landsat TM (www.zulu.nasa.gov), c. Quickbird 2002,
d. Quickbird 2006 (Google earth)

In rainy season, Kalijaga River takes many sediment flows and it is precipitated at the mouth of river. Another rill that just adrift on rainy season also takes the sediment and it supplies to this region but in small amount. Meanwhile on dry season, the influence of marine factor even greater than the river flow, so that the sediment particle those are precipitated before in the mouth of Kalijaga River is flowing towards northwest, MGI beach region, as a prospective area for the port. This region undergoes abrasion. Abrasion in this region has an average of 20 m/years between years 2002 – 2006. Commonly, it

(a) QB at rainy season | (b) QB at dry season

Figure 5. Quickbird Imagery at rainy and dry season

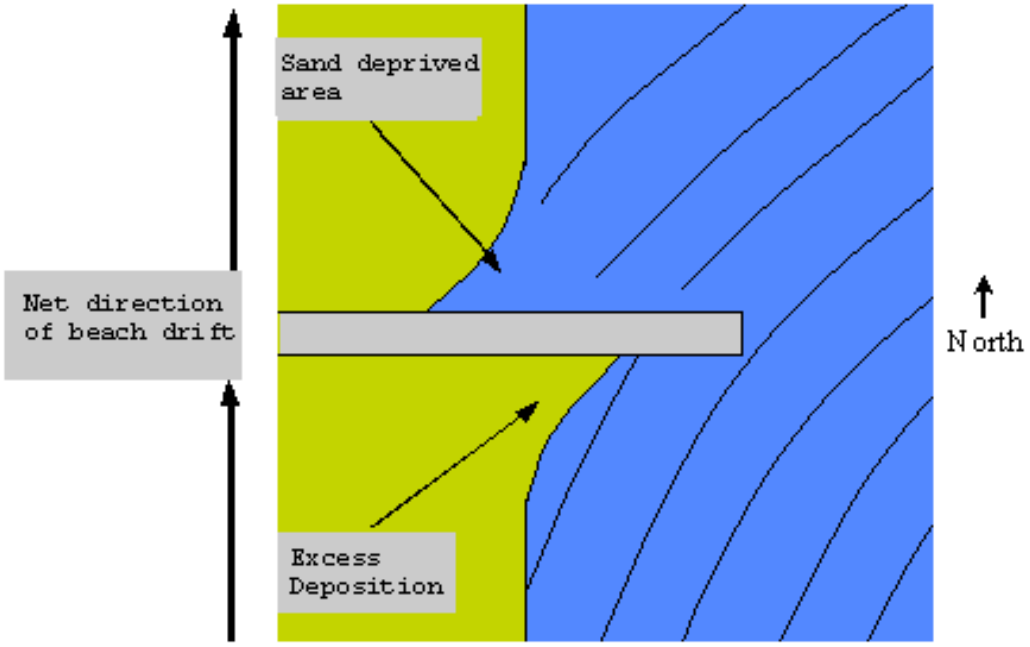

Figure 5. Sketch of the coastal line change beside jetty area
(Modified from http://www.earthscape.org/t1/vip01/vip01c.html)

can be said that the sedimentation main source is come from Kalijaga River.

Mangroves grow up along the coastline at this region, particularly behind MGI office and beside Kejawanan's jetty, except a small area in the northeast at the bay region beside Kalijaga River that constitute abrasion region. The presence of mangrove conduces to support sedimentation process in this region, because of mangrove functions as catchment area and place descent of sediment particles (sedimentation).

Jetty structure in the north of study area gives a major effect to coastline changes. The jetty is interfering with the movement of sediment down current. As sand moves toward the north, it is trapped by the jetty. As a result, sand accumulates on the south side of the structure. However, sand that would normally moves to the north of the jetty is then trapped on the south side of the structure. Figure 5 shows the sketch of coastal line change beside jetty area.

Prediction

Condition of waters behind MGI office (prospective ports planning) constitute calm region because the longshore current that move toward northwest will be stymied by Kejawanan's jetty in the northwest. This situation causes prospective area of port planning until jetty area constitute as sedimentation area.

This sedimentation process caused by sedimentation will be continuing as long as it is supplied by the sediment. In the waters around of prospective port area, the sedimentation process will be continuing. Sedimentation is estimated until equal with Kejawanan's jetty even exceeds it. Similarity with this place, the sedimentation process behind MGI office will follow Kejawanan jetty location in ellipsoid forms. Meanwhile erosion/ abrasion is happening in the eastern part of MGI beside Kalijaga's river and at Kalijaga's estuary. The presence of mangrove in this region really determines coastline changing preferably on erosion region that can prevent and or reduce erosion. On the accretion region, the presence of mangrove conduces to support sedimentation process.

Based on the sedimentation condition that exists in the prospective area, building a port have to consider of this sedimentation. One of the alternatives to build the port is to make a quay pile model which gives way the current to pass through the other side of the port. The long of port model goes away toward mean exceed long of Kejawanan jetty. Another alternative is to build the port as a pond model but it needs accuracy in building the mouth of jetty to minimize the sedimentation process.

CONCLUSION

The water behind MGI office area is an active sedimentation area. The sedimentation main source is predicted come from Kalijaga River. The direction of the sedimentation is parallel to the jetty and its forms ellipsoid, with the sedimentation/accretion region is behind MGI office and the abrasion area in Kalijaga River mouth and a small area beside Kalijaga River. One of the alternatives to build the port is to make a quay pile model which gives way the current to pass through the other side of the port. Another alternative is to build the port as a pond model but it needs accuracy in building the mouth of jetty to minimize the sedimentation process.

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