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COASTAL SEDIMENT CELLS FOR THE NORTH COAST OF EAST JAVA, INDONESIA

Muhammad Zikra
Ocean Engineering Department,
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Suntoyo
Ocean Engineering Department,
Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

Harish Wirayuhanto
Graduate Students, Faculty of Marine Technology,
ITS, Surabaya, Indonesia

ABSTRACT

Sediment cells are spatially discrete areas of the coast within which marine and terrestrial landforms are likely to be connected through processes of sediment exchange, often described using sediment budgets or net sediment transport. They include areas of sediment supply (sources), sediment loss (sinks), and the sediment transport processes linking them. The objective of this study is to present a method to determinate coastal cells that was applied in the north coast of the East Java Island, Indonesia. This work is based on secondary data, various satellite image data and fields survey. The coastal cell boundaries were classified into three type; namely, static, dynamic, and convergent. Twelve sediment cells were identified in the north coast of the East Java. Also, in certain parts of the northern coast of East java can be found sub cell boundaries. These coastal cells help in a more planned approach to coastal planning and management in Indonesia.

Key words: sediment cell; East Java; coastline management.

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1. INTRODUCTION

Almost half of the world's populations live in coastal areas, where humans interact with nature with the consequences unpredictable and undesirable. Lack of understanding of the processes that occur in coastal areas causes the things that are not desirable. Meanwhile, the natural process associated with coastal areas take place in space and time variations. The

coastal area is a dynamic environment where erosion, sediment transport and deposits contributed continuously to the physical changes of the area. This dynamic process requires energy as a driving force in the processes that take place on the coast.

Changes in the coastline due to natural processes of climate change and human activity are important issues that frequently occur in Indonesia, including the northern coast of East Java. As an archipelago country, Indonesia is very vulnerable to climate change such as sea level rise, warmer ocean temperature and increased of wave height [1]. Handling these problems have not provided adequate results even in many cases have failed. This is due to a lack of understanding of the natural processes that occur and the influence of human activities on these processes in coastal areas. By understanding the natural processes and the impact of human activity on the circulation patterns of sediment in coastal areas, both locally and regionally, then planning coastal development, both in the context of disaster mitigation of erosion and its utilization as a means of industry and tourism will be done optimally.

The northern coast of east Java is experiencing numerous human interventions and a lot of damage caused by erosion and sedimentation. Coastal erosion often occur along the coast are not uncommon impact on damage to transportation infrastructure, land aquaculture, tourism facilities etc. Also, east Java's northern coast is a major transportation route of Java-Bali which indirectly is an area that is experiencing rapid growth in various fields. Such growth will have an impact on coastal conditions and pressures on coastal lands surrounding conditions.

Due to various human activities, development activities in northern coast of east Java need to be consider the circulation patterns of sediment movement, both locally and regionally. Planning and policy implementation in this area need to be equipped with accurate information on coastlines data. Therefore, the purpose of this study is to identify and to define sediment cells along the north Coast of East Java. Because, by identify areas of coast where sediment cells estimates may provide a useful tool for supporting integrated coastal planning and management at time and space scales. [2][3][4]

2. STUDY AREA

Sediment cell boundaries were mapped and identified in ten regions district along the north coast of east Java. The position of east Java province is located at 111o – 114o 4 ' E and 7o 12' – 8o 48 ' S as presented on figure 1. The north and east part of east Java bordering with the Java Sea and Strait of Bali. In the south and west part, the area is bounded by Indonesia Ocean and Central Java province. Nearly two-thirds of East Java area consists of mountains and hills, and the rest is lowland.

Table 1 Study Area

No	Region/Districts
1	Tuban
2	Lamongan
3	Gresik
4	Surabaya
5	Sidorajo
6	Pasuruan
7	Pasuruan City
8	Probolinggo
9	Probolinggo City
10	Situbondo

Air temperature in the province was varied between 17° C - 30° C with the humidity is between 70% - 80%. Rainfall in this area is relatively low compared with other provincial regions in Java, which ranges from an average of 2000 mm annually. For this study, ten districts region along the shorelines of north coast in east Java were analyzed as shown in Table 1.

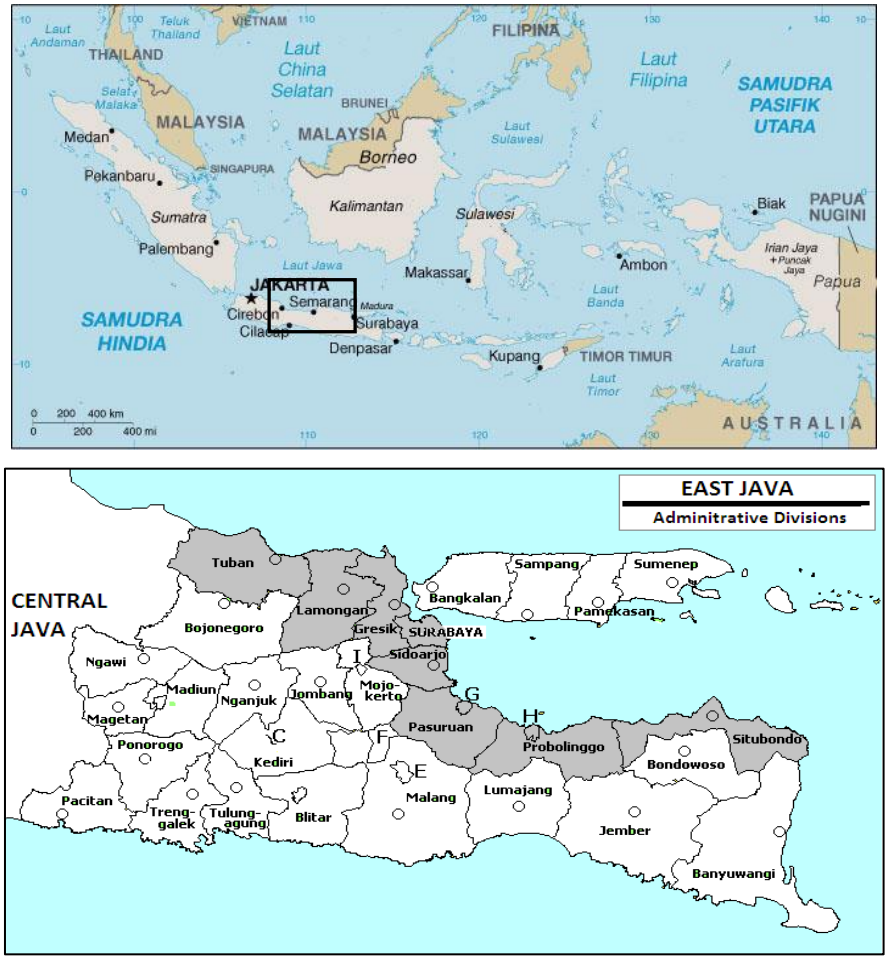


Figure 1 Indonesia Map (top), Study Area of East Java Province (bottom)

3. DATA USED

This study is based on the concept of coastal cell (sediment budget). The concept of coastal cell actually is one of the new approaches in the management of the coastline. Coastal cells are defined as coastal compartments containing the complete cycle of erosion, deposition, sediment sources (supply) and sinks (loss) and the transport paths involved (which sediment is moved between source and sinks) [5,6,7,8,9]. Cell sediment is an integral balance of sediment in and out. Sediment sources within a cell can be derived from longshore transport due to current, sediment from the river and estuary, sea-cliff erosion, onshore transport due to wave, biogenous deposition (shell and coral fragments), wind transport and artificial nourishment (reclamation of beaches). Sediment cells are generally identified as self-contained where little or no sediment movement occurs across cell boundaries [9].

The direction of sediment movement within a cell along the coast and topographic beach features are an important part that will be studied in this study. Sediment transport directions along the beach can be identified based on the morphology of the beach (the shape and pattern of coastline), direction mouth of the river estuary, location of sedimentation and erosion on

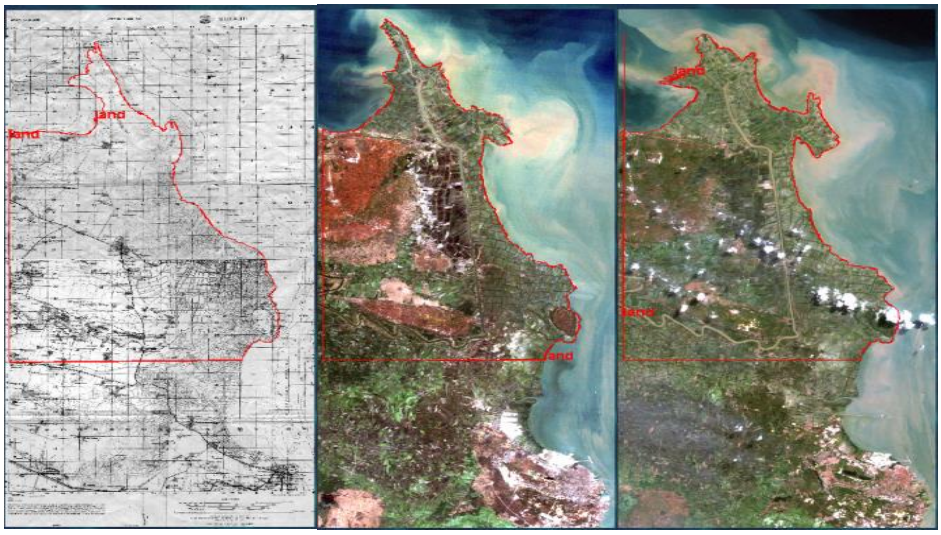
coastal structures like jetty, groin and breakwater, location and pattern of abrasion, accretion and erosion of beaches as well as pattern recognition and coastal geomorphology shape that causes the influence of the movement of sediment, such as sand spit.

In this study, sediment cells boundary divided into three types, namely, static, dynamic and convergent. Static cells boundary is based on the historical record of the coastline stability over the next 20 years to 100 years (as seen on Figure 3). The form of these boundaries is headland or inlet but can also be coastal structures that still survive during this period. Dynamic cells boundary is generally that has broad character and limited stability. This limit can be either delta or promontory as dynamic limits. Convergent boundaries are points at which sediment transport paths meet.

In general, the approach of this study is carried out by collecting data and information from secondary data, satellite image data and field survey. The secondary data such as: tidal data, wind and wave climate data, bathymetry data, beach slope and shoreline data are collected to identification the causes of erosion, abrasion and accretion. The use of remote sensing data to interpretation and identification of parameters that influence the direction of sediment transport like coastal morphology (shape and pattern of coastline) as shown in Figure 2, shape of the river mouth, the location of sedimentation and erosion on coastal structures, shape geomorphology beach.

(a) (b)

Figure 2 River Mouth Change at Ujung Pangkah, Gresik. (a) August 1994 and (b) May 2004



(a) 1964 (b) 1994 (c) 2004

Figure 3 Historical Coastline Change in Ujung Pangkah, Gresik

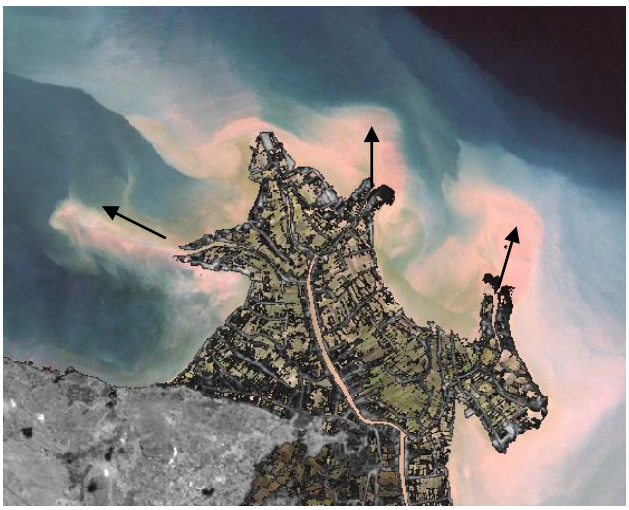


Figure 4 Sediment Source at Ujung Pangkah River Mouth

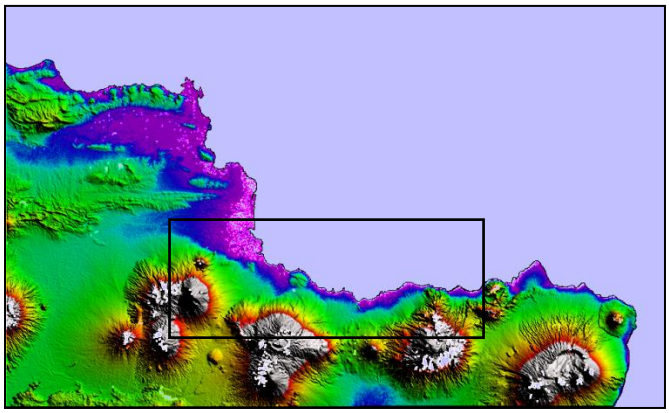


Figure 5 Colordraping Landsat Image with DEM.

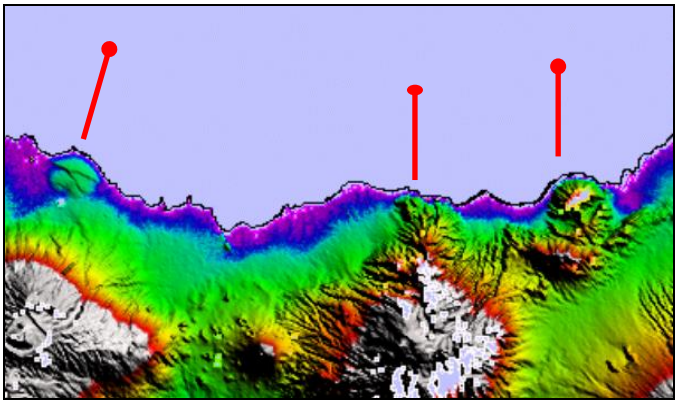


Figure 6 Headlands as Static Boundaries Cell.

4. RESULTS AND DISCUSSION

Twelve coastal cells were identified on this study as presented in Figure 6. Coastal boundary cells that have been identified is generally in the form of natural cell boundary, consisting of headland as the static limit, delta and river estuary or headland results alluvial deposits as dynamic limit and meetings directions of sediment transport as convergent boundaries are also included in this study. Based on data analysis has been carried out in this work, the northern coast of East Java from Situbondo Regency until Tuban district has been defined in

12 twelve coastal cells as presented in Table 2 below: The distance between each cells boundary is varying around 5-50km. Static cells boundaries can be found in the area Situbondo (Wonorejo, Klatakan, and Pasir Putih), Pasuruan (Pulo Pancikan), Gresik, Lamongan (Labuhan). While the dynamic cell boundaries can be found in Sidorajo (Muara Porong) and Gresik (Ujung Pangkah). Convergent boundaries can be found in Tanjung Pecinan (Situbondo district) and Gending (Probolinggo district).

Situbondo region present 3 coastal cells (as seen in Figure 7), the features of the coastal cells boundary as follows: cell number 1 (one) (from Wonorejo village to Tanjung Pecinan) is static cell boundary. This cell is influenced by the form of alluvial volcanic mountain. Sediment transport around jetty showed that sediment is moving toward to the West-Northwest. Cell number two is coastal cell from Tanjung Pecinan to Klatakan. The geomorphological features in this area are alluvial plains (from district Mangaran to the district Panarukan) and a hilly structural denudasional in the district of Kendit, Panarukan. The third cell is small cell from Klatakan to Pasir Putih. This cell is entirely a hilly denudasional structure. Due to natural geomorphological features, the function of these cells as storage and as a source of sediment when there is abrasion in this area.

Probolinggo region present coastal cells number 4 and 5. For fourth cell, boundaries cells located in Pasirputih and Banyuglugur as static cell. In fourth cell, there is also a dynamic sub cells in the form of river mouth in Demung, Suboh regency. Similar with third cell, cell number five have small distance that stretches along the hills between Banyuglugur and Bhinar. From geomorphological features, the form of this cell is a denudasional hill which is a static cell. The beach along this area is quite steep with rocky material.

Pasuruan region present 2 coastal cells (cell no. 6 and cell no. 7). The sixth cell is quite long, covering almost the entire northern coast of Probolinggo and Pasuruan district. Both sides of the boundary cell were a static limit, with some dynamic cells in Sukokerto in the form of river mouths. Convergent boundaries also found in the district of Gending, district of Dringu (Probolinggo city), Sumber Asih and Tongas district (Pasuruan districts) as shown in Figure 7.

As well as the sixth cell, the seventh cell is also quite long and stretches covering Pasuruan district, Sidoarjo district, Surabaya city and some part of Gresik district. In this cell, cell boundaries are indentified in Semedusari (in southeasth) and Pulo Pancikan area (in north). Both cell boundaries are static boundaries. Lekok ponds can be identified as the sink area which is also a convergent boundary. Dynamic boundary in this cell is founded at the river mouth of the Porong River in Sidoarjo regency. The beaches material in this area is mostly silt or fine sand. Sediment transport directions towards North and South of Porong river estuary.

Gresik region present two coastal cells (cell 8 and cell 9). The eighth cell located between Pulo Pancikan and Kramat Pangkah. Cell boundary in Pulo Pancikan is static cells. In Kramat Pangkah, the cell boundary is dynamic boundary, because it is a branch of the estuary of Bengawan Solo. The beach in this area is quite flat. Sediment transport directions in this within the cell boundaries are heading toward the North. For cell no. 9, it is located between Kramat and Ujung Pangkah. Both cell boundaries in this cell are dynamic boundary. As river mouth of Bengawan Solo river, the coastline change in Ujung Pangkah is a very dynamic. This coastal sedimentary material is mud and fine sediment. The slope of beach is very gentle in this cell.

The tenth and eleven cells are located in Lamongan district region. The beaches around the tip of Ujung Pangkah river mouth in general are flat, while the surrounding area of Weru is rather steep. Based on coastal geomorphological conditions, the shape of the beaches are denudational hills and rather steep. The sediment transport in this cell moving to westward direction. In cells eleven, cell boundaries are indentified in Weru and Brondong region. Both cell boundaries are static cell. The beach in this cell area is mostly steep and hilly, while in other areas is sloping beach. Based on sediment sample analysis can, it can be identified that the sediment transport direction is headed west.

The twelfth cell is located in Tuban region. Based on data analysis, it can be identified that the cell boundary in the east of this cell (Brondong) is static limits, as well as in the west of this cell (Bancar area). In this cell, the shape of the beach is alluvial plain with a sloping slope. The direction of sedimen transport indicated that sediment moving to the east from Bancar area and from Brondong area toward to the west.

Table 2 Location of cell sediment results

Region/ District	Sediment Cell	Location
Situbondo	Cell 1	Wonorejo, Banyuputih district until Tanjung Pecinan, Mangaran district
	Cell 2	Tanjung Pecinan until Klatakan, Kendit district
	Cell 3	Klatakan until Pasir Putih, Mlandingan district
Probolinggo	Cell 4	Pasir Putih until Banyuglugur, Besuki district
	Cell 5	Banyuglugur, Besuki district until Bhinar district. Paiton
Pasuruan	Cell 6	Bhinar district, Paiton, until Semedusari, district, Pasuruan
	Cell 7	Semedusari district until Pulo Pancikan, Pasuruan
Gresik	Cell 8	Pulo Pancikan until Kramat, Gresik
	Cell 9	Kramat- Ujung Pangkah, Gresik
Lamongan	Cell 10	Ujung Pangkah, Regency Gresik until Weru, Lamongan
	Cell 11	Weru until Brondong, Lamongan
Tuban	Cell 12	Brondong until Bancar, Tuban

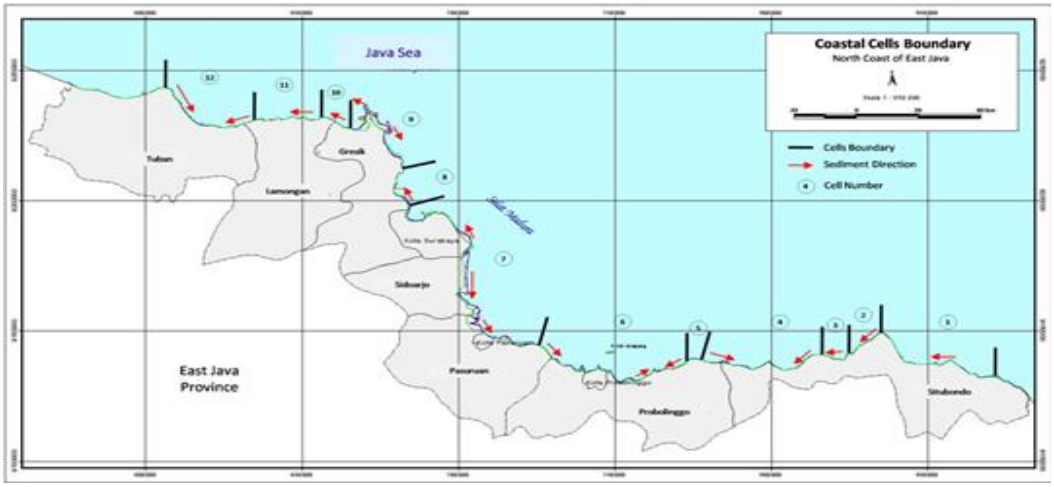


Figure 7 Coastal Cells Boundary

5. CONCLUSIONS

This work is based on secondary data, various satellite image data and fields survey to determine and to analyze coastal cells. The coastal cell boundaries were classified into three type; namely, static, dynamic, and convergent. Twelve sediment cells were identified in the north coast of the East Java Island. In certain parts of the northern coast of North Java can be found sub cell boundaries. Based on the analysis of morphological changes in the river estuary since 1964 to 2003, Solo and Brantas River is the largest sediment supply in the northern coast of East Java. These coastal compartments help to facilitate better integration of coastal management decision-making between governance, stake holder and engineer at a regional and local level.

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