

Study of Sediment Transport Rate in Jeneberang Estuary, Case Study of Active Tombolo Emergence in the South of Estuary

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Abstract

Sediment movement continuously at the mouth of the river causing erosion and sedimentation and shoreline changes in the area around the estuary. Introduction behavior sedimentation in the estuary is an important initial step in determining step efforts to address the problem of sediment deposition and movement. This study aimed to determine the pattern of propagation of waves and currents and their effects on sediment and Tombolo active or cusped appearance. The methodology used in data collection is to perform direct measurements and the data obtained is processed by software based on finite difference especially for the analysis of wave propagation patterns and sediment movements. The results of the study conducted in the southern estuaries Jeneberang shows that the propagation pattern of waves and currents affect the movement of sediment and the intersection between the two causes that trigger the appearance of sediment deposition on Tombolo active or cusped.

Keywords: tombolo active, sediment, waves, currents.

INTRODUCTION

A river is a natural channel that extends over a relatively long distance and may have many tributaries, flowing from higher elevations across lowland areas before terminating in a basin such as a lake, marsh, sea, or other depression. Rivers exhibit various flow patterns, including flow in straight channels and flow in branching channels formed by the confluence of two rivers. As rivers extend from high elevations to lower-lying areas, they carry various materials, including sediment, which may subsequently be deposited in the sea.

A river mouth is the part of the coastal water body at the seaward end of a river, forming the boundary between the river outlet and the sea. The characteristics of a river mouth or tidal inlet are influenced not only by river discharge from upstream and tidal movement but also by ocean waves, because the area is located offshore.

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Observation Area Conditions

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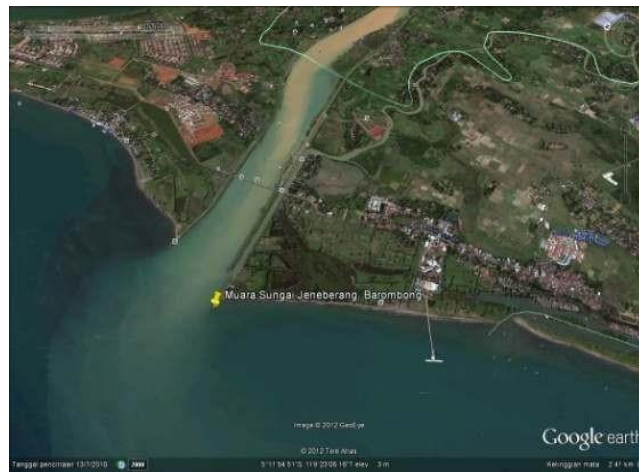


Figure 1. Satellite image of the Jeneberang River mouth

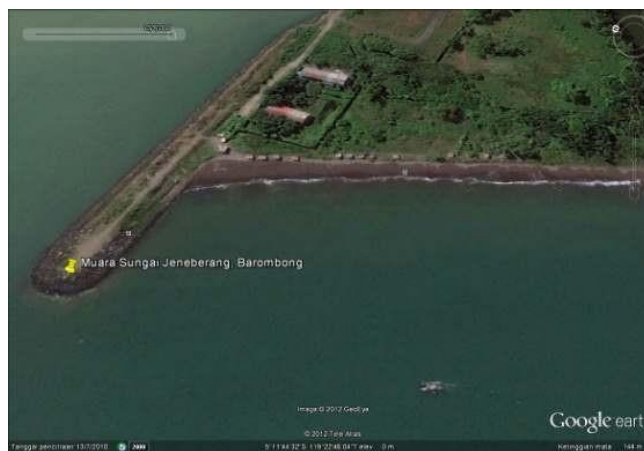


Figure 2. Enlarged satellite image of the southern part of the Jeneberang Estuary

Batimetri

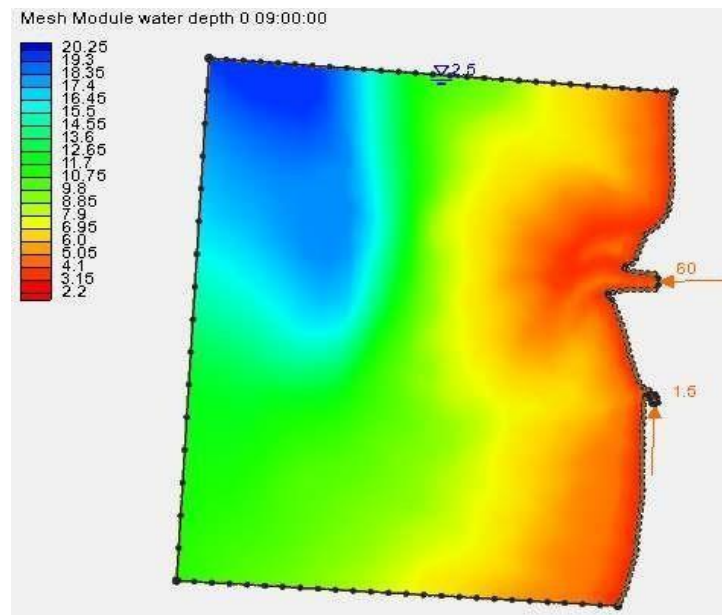


Figure 3. Bathymetric conditions at the study site

The bathymetric data processed using SMS show evidence of sediment deposition. As illustrated in the figure above, this deposition occurs in the area around the mouth of the Jeneberang River.

Sediment

Sediment data were obtained by measurements using sediment traps installed according to the cardinal directions for 24 hours. The trapped sediment was then dried and weighed. The measurement results are presented in the following table:

Table 1. Sediment Weight by Cardinal Direction

Direction	Sediment Weight (g)
North	95.314
South	94.165
West	52.457
East	—

The table indicates that longshore sediment transport is predominantly directed northward, with a reported amount of 95.314 g/day. This is consistent with the dominant northward current at the study site, toward the mouth of the Jeneberang River. In contrast, onshore–offshore sediment transport is predominantly directed outward from the western side, with a reported amount of 52.475 g/day.

Based on these data, the shoreline at the study site tends to experience erosion because the amount of sediment leaving the area is greater than the amount entering it. In addition, sediment transported offshore tends to move toward the southern part of the Jeneberang Estuary, potentially causing shallowing south of the study area.

After drying and weighing, the sediment was sieved to determine the particle-size distribution at the study site. The sieve sizes used were 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm, 0.063 mm, and less than 0.063 mm. The results are presented below

Table 2. Sieve Analysis Results and Sediment Particle-Size Distribution

Sieve No.	Diameter (mm)	Weight		Percent (%)	
		Retained (gram)	Weight (gram)	Retained	Pass
4	2	0	0	0	100
10	1	0.040	0.040	0	100
16	0.5	1.069	1.109	1	99
40	0.25	5.492	6.601	6.93	93.07
60	0.125	49.183	55.784	58.53	41.47
120	0.063	37.402	93.186	97.77	2.23
200	>0.063	2.128	95.314	100.00	0.00
Pan	-	0.00	95.314	100.00	0

The sieve analysis shows that 58.53% of the sediment was retained on sieve No. 60. According to the Wentworth classification table, the sediment in the eastern direction is very fine sand with a diameter of 0.125 mm and is non-cohesive. It can therefore be readily transported by waves and currents, facilitating littoral transport at the study site

Waves

The wave-transformation model for the study site was adapted to the shoreline configuration and the wind direction capable of generating waves. The wave-transformation model was obtained by running the CGWAVE program, which produced outputs including bathymetry, wave height, wave period, and wave-propagation direction. The results are shown below:

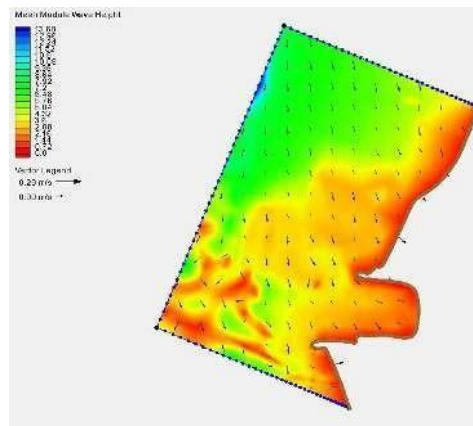


Figure 5. Wave height and propagation direction for waves approaching from the northwest

Wave trains approaching from the northwest propagate in a direction that tends to become parallel to the shoreline; however, as they approach the coast, their propagation direction is refracted. Wave-propagation direction is indicated by arrow vectors ($\rightarrow$). Wave heights range from 0.72 to 5.76 m. This indicates that the generated waves may be sufficiently large to transport greater quantities of material. This is consistent with Triatmodjo (2008), who stated that large waves transport more sediment per unit time than small waves.

Currents

Measurements using a current-drogue method were conducted to determine the dominant current direction. The data obtained are shown below:

Table 3. Current-Direction Measurement Results at Points A and B

Point	Time (s)	Directions	Point	Time (s)	Direction s
A	0:13	N	B	0:38	N
	0:23	N		0:18	W
	0:26	N		0:43	N
	0:25	N		0:21	N
	0:23	N		0:31	N

The current-direction measurements were conducted at two points (A and B) in the southern part of the Jeneberang Estuary, with five observations at each point. The results show that the current generally flows northward (N). At each point, the direction was northward in four of the observations on average, with a reported average current time of 20 seconds. This indicates that sediment transport tends to occur toward the north.

Current modeling was also carried out using the Surface Modeling System (SMS) with the RMA2 module. The modeling was intended to examine current directions and tombolo positions during the west and east monsoon seasons. The results are shown below:

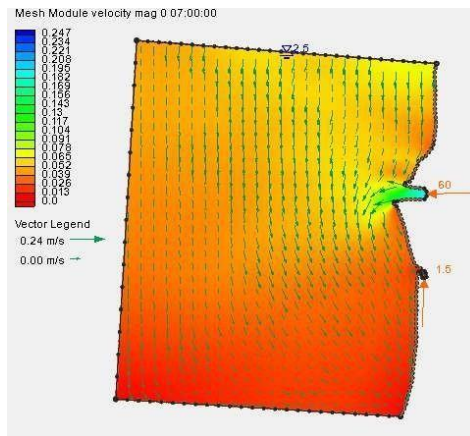


Figure 6. Tombolo position during the west monsoon

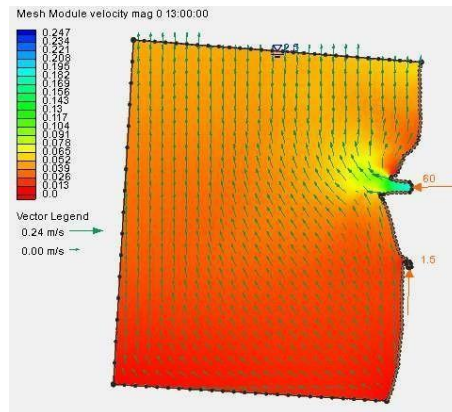


Figure 7. Tombolo position during the east monsoon

The RMA2 current-model results for the southern part of the Jeneberang Estuary indicate the occurrence of turbulence in this area. This suggests the presence of a landform associated with the development of an active tombolo. During the west monsoon, the active tombolo is observed near the shoreline. The season is characterized by currents flowing from the north (Hutabarat & Evans, 2012).

Figure 6 shows that the tombolo initially formed near the shoreline, at a water depth of 0 m. Its subsequent movement away from the shore follows the north-originating current. This indicates that current direction determines the direction of active tombolo movement. The longshore current generated by waves approaching from the north forms an angle with the shoreline and is obstructed by the jetty at the study site. Consequently, the river current carrying sediment is impeded south of the Jeneberang Estuary.

During the east monsoon, when currents flow from the south, Figure 7 shows that the tombolo is located north of the Jeneberang Estuary. This may be caused by the influence of the south-originating current, which results in tombolo formation in that area

CONCLUSION

Based on the research results, the following conclusions were obtained:

1. The wave-propagation pattern in the southern part of the Jeneberang Estuary originates from the northwest, forms an angle with the shoreline, and is obstructed by the jetty at the study site. Consequently, the river current carrying sediment is impeded south of the Jeneberang Estuary.
2. The results show that sediment movement is influenced by the wave-propagation pattern in the southern part of the Jeneberang Estuary. The waves imply that sediment transport moves along the shoreline from north to south. Sediment accumulation in this area leads to tombolo formation, as demonstrated by the RMA2 results, in which the tombolo moves near the shoreline in the same direction as the southward sediment transport.



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