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Abstract. Based on the geological records, the tsunami in 2004 has resulted in coastline shifts along the west coast of Aceh. One of the beaches in the western region that undergoes a major coastline change is Lampuuk beach. This study aims to determine the shoreline changes occurring at Lampuuk beach. The study of coastline changes was done by utilizing remote sensing using satellite imagery and geographic information system. Geographic information systems were used to analyze spatial data obtained from multitemporal satellite imagery before and after the tsunami disaster. The results show that coastline changes occur very significantly during the 2004 tsunami and persisted until 2005, but after 2010 the coastline was back to normal. During 2001–2005 there was a reduction in coastal plains caused by the 2004 tsunami waves. In 2005-2018 the sedimentation process at Lampuuk Beach was more dominant, assisting to adjust the shape of the coastal profile as before the 2004 tsunami. The results also show that the Lampuuk area was more sedimentary than erosion.

1. Introduction

Aceh is an area located at the end of the Sumatra fault known as the great Sumatra Fault (fault of Semangko) and vulnerable to the threat of geological disaster [1], one of which is the tsunami disaster. The highly vulnerable area of the tsunami lies along the West Coast of Aceh bordering the Indian Ocean [2]. Based on the tsunami geological records that occurred in 2004 has resulted in coastline shifts along the west coast of Aceh. One of the beaches in the western region that changed the shoreline is Lampuuk beach. This beach is located in Meunasah Mosque Village, Lho'nga District, Aceh Besar District.

The shoreline change is a process that occurs through various processes and occurs continuously [3]. Shoreline changes can be affected by coastal abrasion and accretion [4-5]. Coastal abrasion is a condition in which the coastline progresses towards the land while coastal accretion is a condition where the coastline is increasingly retreating towards the ocean [6]. the depression and abrasion that occur on the coast can be affected by ocean waves, sediment deposition and transportation [7].

Shoreline changes can also be caused by tsunami waves. The tsunami that occurred in 2004 was a tsunami that was very severe and very influential to the changes in coastline that occurred along the West Coast of Aceh. Tsunami waves are waves with very large energy and the waveform extends from the sea floor to the surface so that the tsunami waves produce enormous energy that can cause shoreline changes [2].

Not only by the tsunami, the shoreline changes are also caused by the dynamics of the sea such as waves, tides, currents and geological conditions (geomorphology) and geographical location [8-9]. The process of marine dynamics results in coastal abrasion and accretion while the geological conditions that cause coastline changes are coastal sedimentation processes [10-11]. Sediments are the main ingredients for topographic and coastal bathymetry so that the mechanism of erosion, sediment transport and sedimentation leads to shoreline changes [12]. Therefore, the shoreline changes that occur at the beach of the lights need to be studied because the beach is a tourist beach so that spatial analysis is needed to determine the current status of the coastline. The purpose of this research is to study how the condition of the shoreline changes that occur before and after the tsunami in Lampuuk Beach.

2. The methods of the research

Data obtained directly from the research location was processed using ArcMap. Spatial data analysis of shoreline changes was done in several stages: image collecting, georeferencing, on-screen digitization and image overlay. The imagery to be used in this study was a multitemporal satellite imagery obtained free of charge from the Google Earth Pro software. By using ArcMap shape file, georeferenced was made to adjust the coordinates of the field where the data was taken. While on-screen digitization was done to differentiate the shoreline on each image so that the shoreline changes can be seen. Finally, the overlay was made to see the shoreline difference in each image by combining the image data recorded in different years.

The image used in this research was satellite imagery obtained for free from the Google Earth Pro software. Satellite imagery used is satellite imagery in 2001, 2005, 2010, 2011, 2013, 2015, 2017 and 2018. Geometric correction was done using ArcMap by activating georeferencing tools. Georeferencing was carried out by providing a coordinate system at several reference points at the research location. The provision of coordinate systems in the image according to the coordinate system used was 1984 WGS datum zone 46 N.

3. The Results and discussions

Changes in the coastline that occurred due to the influence of the tsunami waves in 2004 can be seen in Figure 1. In 2001 the coastline was closer to the shore while in 2005 there was an abrasion because of the influence of the 2004 tsunami wave so that the coastline progressed towards land. Abrasion caused by the 2004 tsunami caused the land area to decrease by 118668.4 m^2. The reduction in land area caused by the tsunami wave was very large because Lampuuk Beach had a very gentle slope (0-2%) so it was unable to withstand tsunami waves and triggered a large abrasion. Very gentle coastal slope conditions (0-2%) can cause high waves when tsunami waves approach the coastline. High tsunami waves are caused by wavelengths that are shortened due to the effect of reduced wave velocities as they approach sloping coastlines [13].

Table 1 shows that during the year of 2005 - 2010 there was an abrasion of 4681.92 m^2 and accretion of 44779.36 m^2 causing the addition of coastal area of 40097.44 m^2. It can be seen that the impact of coastline changes by the 2004 tsunami disaster at Lampuuk beach only had a temporary (non-permanent) impact. This evident can be seen from the analysis of shoreline changes in 2010 where the coast began to reside and rebalance its position as it was before the 2004 tsunami. Nevertheless, some changes can not be resumed as originally caused by marine dynamics and coastal topography [14].

Table 1. Abrasion and accretion at Lampuuk coast in 2005 to 2018

	Year							**Average/ years (m^2)**
	2005 - 2010	2010 - 2011	2011 - 2013	2013 - 2015	2015 - 2017	2017 - 2018	2005-2018	
Abrasion (m^2)	4681.92	362.12	2440.59	6236.05	2764.37	1836.79	-	2617.40
Accresion (m^2)	44779.36	14584.84	5040.83	2588.94	11655.19	4812.71	64968.47	21204.33

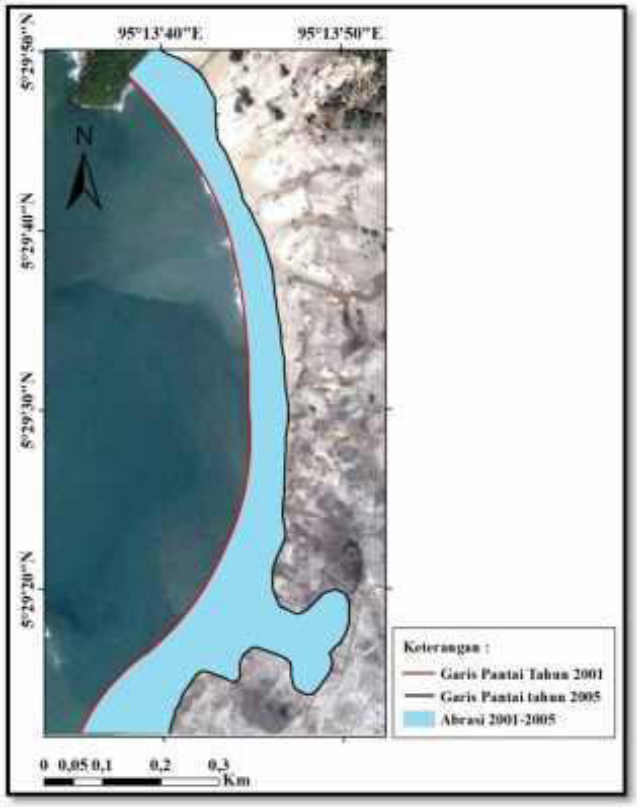

Figure 1. The spatial condition of coastline changes from 2001 - 2005.

The influence of the large waves caused by the 2004 tsunami has caused the coastal plains to experience a large erosion, which has changed the shape of the coastal profile. The influence of the normal wave coming and the process of deposition of coastal sediments after the tsunami can help adjust the shape of the beach profile back to its original shape. Sediments deposited not too far from the beach because of the current carried by the tsunami wave can be transported back to shore by the influence of normal waves so as to help adjust the shape of the beach profile so that it can return to its original profile [15].

Adding sediment to the coastal plains causes the coastline to experience more sea-going swings. Sediments transported to the coastal plain are carried by currents and waves so that marine sediments

are transported and deposited along the coastline. Sediments transported to Lampuuk Beach can also come from the Lampuuk Beach cliff which is continuously eroded and eroded by ocean waves (Figure 2). The cliff at the end of Lampuuk Beach consists of a unit of carbonate limestone with mineral calcite making it can be eroded by water. The presence of chemical reactions from seawater and rainwater to carbonate rocks causes a continuous erosion of cliffs and causes the addition of sediment on the coastal plain [16].

Figure 2. Lampuuk Beach cliffs are eroded by ocean waves.

Figure 3 shows the state of Lampuuk shoreline in 2005 (after tsunami affected) and its change in 2010. By looking at the comparison of changes occurring during 2005 to 2010, it can be concluded that coastal erosion caused by tsunamis in the eastern region of eastern Lapuuk beach for five years has been re-sedimented so that the changes change from erosion to sedimentation.

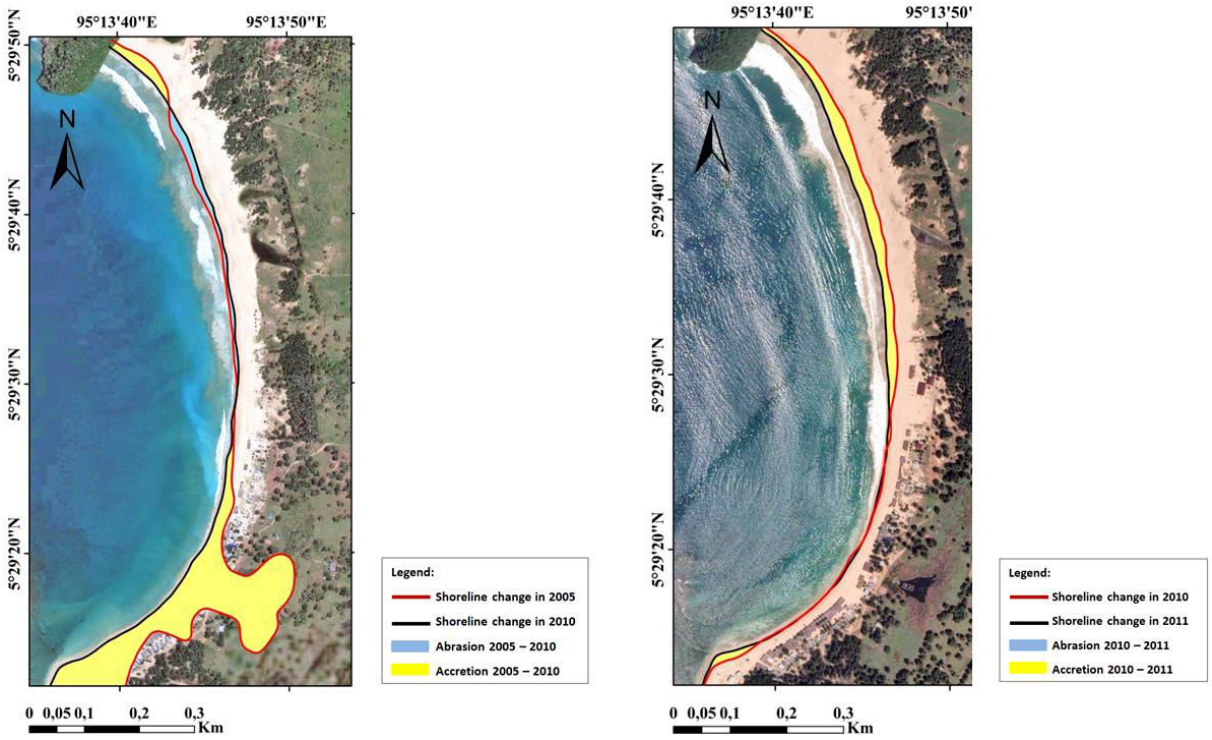

Figure 3. Shoreline change in 2005 after the tsunami 2004 compared to the condition in 2010.

Table 2 shows the addition and reduction of the Lampuuk coastline. The average abrasion / year that occurred during the last 14 years at Lampuuk beach is 2617.41 m2 and the average accretion that happened annually in Lampuuk beach is 21204.34 m2. This indicates that the addition of coastal areas that occur in Lampuuk beach is greater than the reduction of coastal areas that occur. The addition of coastal areas due to the sedimentation process causes the shoreline shifted towards the sea.

Table 2. addition and reduction of the Lampuuk coastline area

Year	addition and reduction (m^2)	Dominant change
2005 - 2010	+40097.44	Sedimentation
2010 - 2011	+14222.72	Sedimentation
2011 - 2013	+2600.24	Sedimentation
2013 - 2015	-3647.11	Erosion
2015 - 2017	+8890.81	Sedimentation
2017 - 2018	+2975.91	Sedimentation
2005-2018	+64968.47	Sedimentation

The shoreline changes that occurred at Lampuuk beach were enormous during the 2004 tsunami and persisted until 2005. These changes are gradually recovered by the presence of sedimentation. Until 2010, the shoreline changes no longer significantly changed due to Lampuu beach topography and sea dynamics processes. The dominance of coastline changes in Lampuuk is more sedimentation than erosion.

4. Conclusion

The shoreline changes that occurred at Lampuuk beach were enormous during the 2004 tsunami and persisted until 2005. These changes are gradually recovered by the presence of sedimentation. Until 2010, the shoreline changes no longer significantly changed due to Lampuu beach topography and sea

dynamics processes. The dominance of coastline changes in Lampuuk is more sedimentation than erosion.

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