International Journal of Oceans and Oceanography
ISSN 0973-2667 Volume 10, Number 2 (2016), pp. 235-246

http://www.ripublication.com

Shoreline Change in Tuban district, East Java using Geospatial and Digital Shoreline Analysis System (DSAS) Techniques

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Abstract

This study aimed to compare the shoreline change occurs by combining the two coastlines and five shoreline with a different time using DSAS so as to identify and measure erosion (shoreline retreat) and accretion (shoreline advance) that occur shoreline at the beach Tuban. Shoreline change rates were calculated according to Net Shoreline Movement (NSM), End Point Reference (EPR), and Linear Regression Rate (LRR). The result of DSAS analysis using 2 shorelines (from 1972 to 2015) indicated shoreline retreat with average EPR of 15.25 m/year and average NSM of 650.11m. However, the same analysis using 5 shorelines for the same time period indicated shoreline retreat with average EPR of 15.23 m/year and average LRR of 13.86 m/year. Merge using two shoreline in different time shows the results of a more detailed and very clear so it can be known with certainty at the transect lines which indicate the presence of shoreline retreat and shoreline forward but can not see the trend when compared to combining 5 shoreline.

Keywords: DSAS, Landsat, Shoreline change, the amount of shoreline.

INTRODUCTION

DSAS (Digital Shoreline Analysis System) has been used in various shoreline change studies, e.g. to record shoreline dynamic [1]; shoreline change variation using the shortest amount of time [2,3]; shoreline evolution [4.5]; shore erosion calculation [6,7], modeling shoreline with cliff [8.9]; predicting future shoreline and change trends [10,11] and shoreline change and sea level rise [12]. Digital Shoreline Analysis System (DSAS) works better to analyze shoreline change and observe particular damaged site in smaller areas, while the latest techniques of remote sensing with geographic information system (GIS) has proven to be very useful approach for monitoring coastline changes and more effective than by conventional techniques in terms of both cost and time. DSAS system requires some shoreline of different dates to get the data and results. Some researchers are using the device incorporates several shoreline DSAS [13], both with long time scales and short time scales.

The main objective of this paper is to compare the shoreline change occurs by combining the two coastlines and five shoreline using DSAS so as to identify and measure erosion and accretion

STUDY LOCATION AND DATA SOURCES

Tuban District is one of the 38 districts/cities in East Java Province and situated in the westernmost of the province. Geographically the district is situated in 111º30'-112º35'E and 6º40'-7º18'Sand borders Java Sea to the north, Lamongan District to the east, Bojonegoro District to the south and Central Java Province to the west (Tuban District Spatial Plan, 2012). Therefore, Tuban District is one of coastal city in Java North Coast (Pantura), covering shoreline of ± 65 km from the west to the east. Topographically, the district is of 0-2% slope and 0-7 masl elevation. The present study was carried out across the shoreline of Tuban District, comprised of Bancar, Tambakboyo, Jenu, Tuban, and Palang Districts' shorelines (see Figure 1).

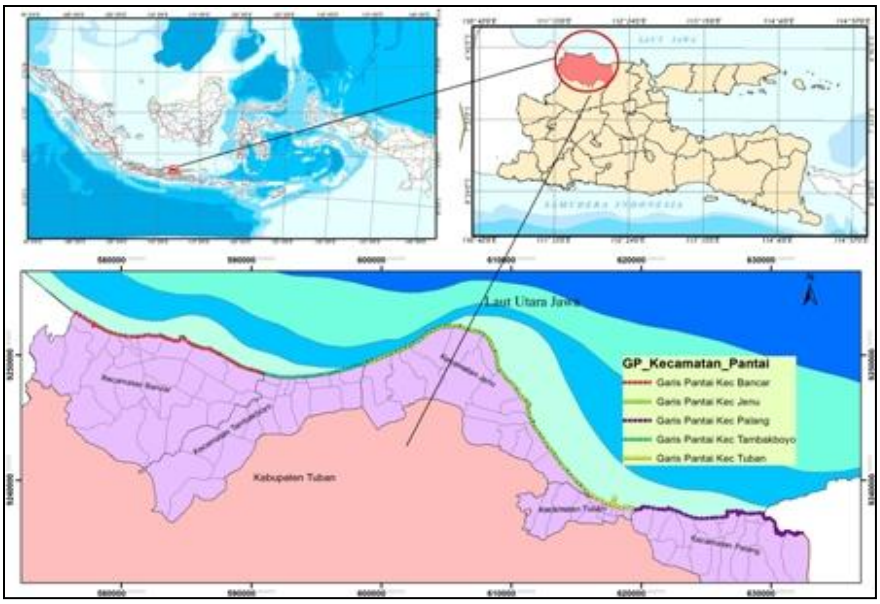

Figure 1. Map of Study Location

This study used landsat multi-temporal satellite imageries to monitor shoreline change. See Table 1 for the satellite imagery data used along with the satellite types and time they were acquired.

Table 1. Multi-temporal satellite imagery data used to obtain shoreline data

Acquisition time	Satellite	Sensor	Resolution (m)
27-09-1972	Landsat 1	MMS	80
09-09-2000	Landsat 7	ETM+	30
20-08-2013	Landsat 8	ETM+	30
24-08-2014	Landsat 8	ETM+	30
22-05-2015	Landsat 8	ETM+	30

METHODOLOGY

Digital Shoreline Analysis System (DSAS) is an Arc Map extension, developed by US Geological Survey (USGS), publicly available, and can be downloaded at http://woodshole.er.usgs.gov/project-pages/dsas/.

DSAS system requires several shoreline data from different date to generate data and result. Shoreline data can be obtained by importing shape file from digitation output or from other technique such as aerial imagery (satellite imagery). Each shoreline data requires their respective date and uncertainty.

See Figure 2 for steps to acquire and determine shoreline for DSAS to analyze in the present study.

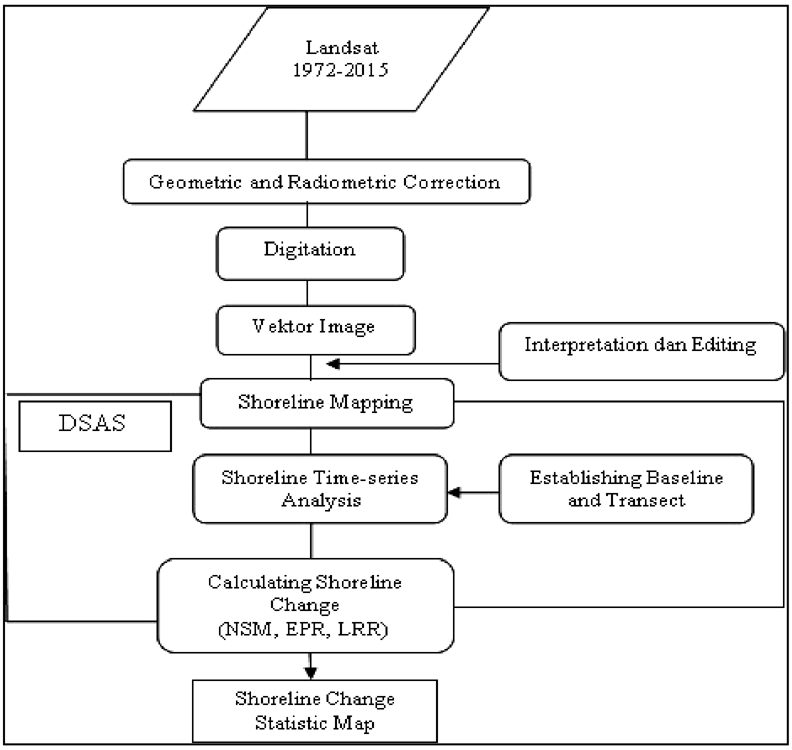

Figure 2. Work steps to Determine Shoreline Change

Satellite imagery used in this study was first geometrically corrected to align the image position with its geographic position, as well as to avoid any mistake in analyzing shoreline change. Image was also re-sampled to align spatial resolution. After being geometrically corrected according to its geographic location, the image was then cropped according to study location, i.e. Tuban District. Shoreline data from geometrically corrected images were obtained through digitation method, namely digitation screen, on monitor using Autocad software. The outcome of the digitized multi-temporal satellite imagery (Landsat) 1972, 2000, 2013, 2014, and 2015 are the shoreline information (Figure 3).

To determine shoreline change using DSAS, there are several steps to carry out, i.e. (1) establishing baseline, (2) set orthogonal transects coastwise, and (3) calculate change rate (NSM, EPR, and LRR).

1. Firstly, baseline was established based on the result of field shoreline survey. Buffer of 500 m to the left and right (to the land and sea directions) of the baseline was made. Baselines made were selected according to the dominating change direction and in parallel with the general shoreline orientation (Figure 4).
2. Secondly, transect lines were established 50 m from each other for ±65 km coast landscape (Figure 5).
3. Third, calculating shoreline change.

   Shoreline change was calculated using general statistic methods, i.e. NSM, EPR and LRR.

   Net Shoreline Movement (NSM): measuring net shoreline change according to distance rather than mean value. NSM relates to date and only two shorelines requires, i.e. total distance between the earliest and the latest of shoreline in each transect.

   End Point Rate (EPR) is calculated by dividing the distance of shoreline change by the time elapsed between the oldest and the youngest shorelines.

   Linear Regression Rate (LRR) is generally used to express shoreline movement and estimate change rate. LRR can be calculated using least squares regression line from all shoreline positions along transect.

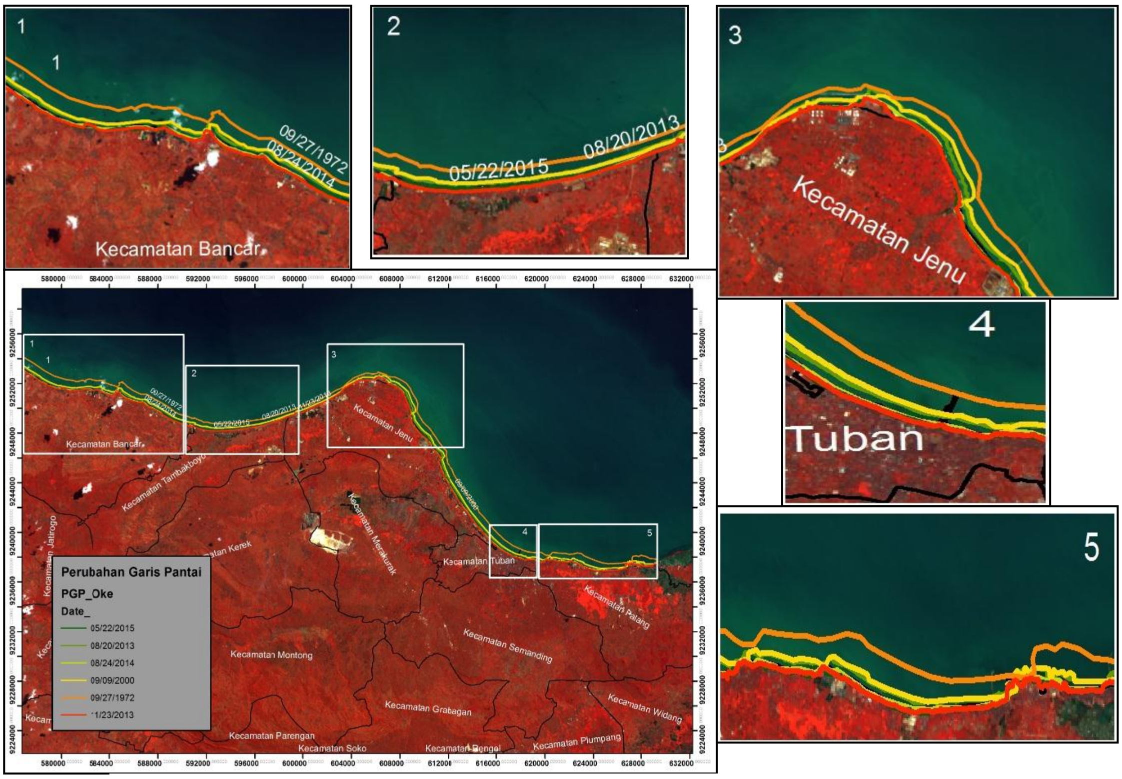

Figure 3. Shoreline Position from Different Year

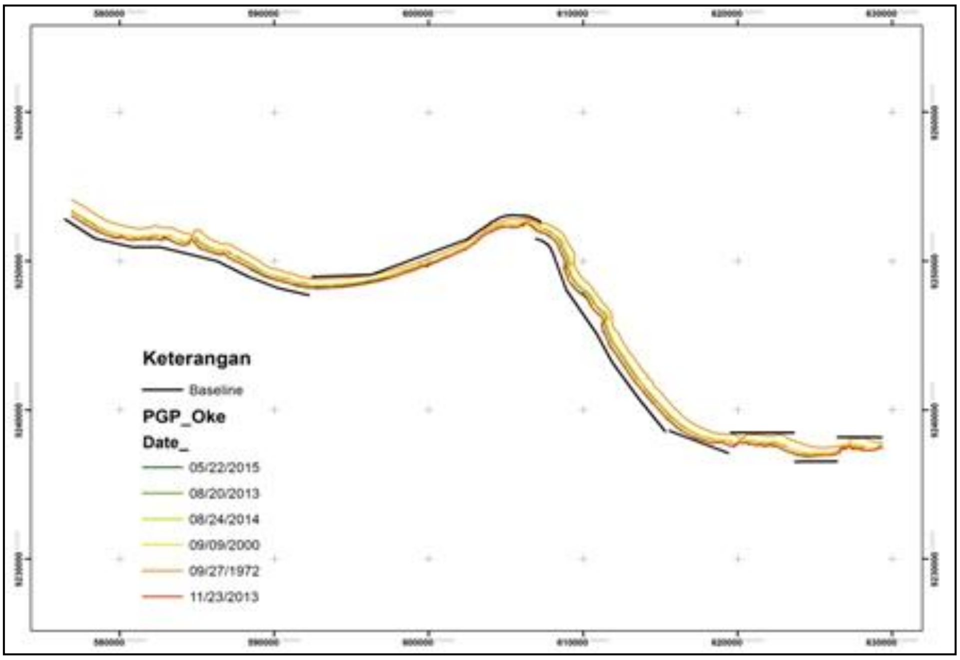

Figure 4. Baseline established from buffer based on field shoreline survey result (October-December 2013)

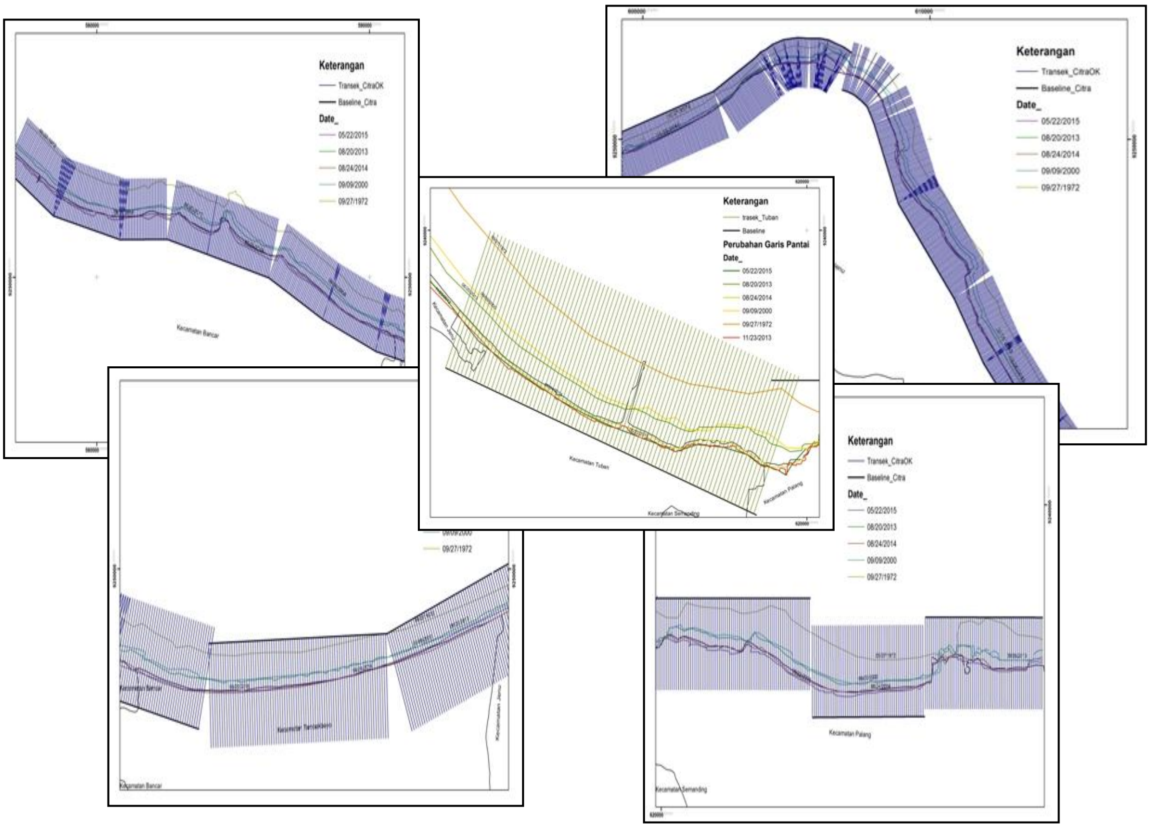

Figure 5. Orthogonal transect lines across shoreline

RESULT AND DISCUSSION

A total of 1265 transect lines 65 km in length spread across 5 coast sub-districts were made using DSAS. See Table 2 for the result of shoreline change using DSAS with 2 shorelines from different years. The result showed that average shoreline retreat (EPR) from 1972 to 2015 across coastal areas of Tuban District was 15.24 m/year with average shoreline movement (NSM)of 650.11 m. Both shoreline retreat and advance were found in coastal area of Palang Sub-District from 1972 to 2000 with average shoreline retreat of 15.73 m/year, average retreat length of 628.32 m, average shoreline advance of 3.28 m/year, and average advance length of 91.73 m. The shoreline advance was found in reclamation area for Karangagung Fishing Port, Palang. Shoreline retreats were also found in other Sub-districts, i.e. Bancar, Tambakboyo, Tuban, and Jenu, with average EPR of14.55 m/year and average NSM of 406.69 m. Shoreline advances and retreats across coastal areas of Tuban District were found from 2000 to 2013, 2013 to 2014, and 2014 to 2015 with average EPR of 3.42, 17.45, and 30.56 m/year, respectively, and average NSM of 44.27, 17.6, and 22.69 m, respectively.

Table 2. Shoreline change for 1972-2015 (using only 2 shorelines from different years)

Coast	Shoreline Change	1972-2015	1972-2000	2000-2013	2013-2014	2014-2015
Palang	Average Shoreline Change (m/year)	14.51	14.85	1.25	14.68	52.28
	Average Retreats (m/year)	14.51	15.73	2.49	15.15	56.87
	Average length of shoreline retreats (m)	618.62	439.59	32.95	15.48	42.24
	Max retreat (m) (Transect no.)	965.73 (183)	628.32 (189)	193.1 (24)	151.21 (11)	130.01 (30)
	Min retreat (m) (Transect no.)	0.52 (13)	131.86 (131)	0.05 (48)	1.76 (53)	0.56 (12)
	Average advances (m/year)	0	3.28	3.70	146.11	71.16
	Average length of shoreline advances (m)	0	91.73	44.68	91.86	52.84
	Max advance (m) (Transect no.)	0	182.02 (13)	302.18 (8)	161.73 (5)	98.26 (4)
	Min advance (m) (Transect no.)	0	8.06 (16)	0.04 (47)	7.87 (124)	14.36 (123)
Tuban	Average Shoreline Change (m/year)	17.73	16.78	3.70	20.69	48.59
	Average Retreats (m/year)	17.73	16.78	4.07	20.69	48.59
	Average length of shoreline retreats (m)	756.00	469.10	52.64	20.89	36.08
	Max retreat (m) (Transect no.)	911.28 (201)	551.75 (196)	84.45 (211)	132.47 (269)	72.34 (201)
	Min retreat (m) (Transect no.)	598.68 (265)	345.16 (267)	9.55 (242)	36.05 (260)	8.54 (277)
	Average advances (m/year)	0	0	1.89	0	0
	Average length of shoreline advances (m)	0	0	24.48	0	0
	Max advance (m) (Transect no.)	0	0	39.85	0	0
	Min advance (m) (Transect no.)	0	0	2.25	0	0
Jenu	Average Shoreline Change(m/year)	14.43	12.70	4.71	17.61	28.82
	Average Retreats (m/year)	14.43	12.70	7.20	17.77	40.46
	Average length of shoreline retreats (m)	615.25	354.86	92.01	79.66	30.05
	Max retreat (m) (Transect no.)	946.88 (375)	623.14 (375)	391.29 (502)	179.43 (502)	169.67 (532)
	Min retreat (m) (Transect no.)	140.35 (620)	77.95 (703)	0.37 (757)	0.54 (757)	0 (494)
	Average advances (m/year)	0	0	2.66	43.16	28.87
	Average length of shoreline advances (m)	0	0	37.33	43.63	21.44
	Max advance (m) (Transect no.)	0	0	233.42 (689)	77.23 (687)	125.77 (685)
	Min advance (m) (Transect no.)	0	0	0.41 (701)	12.58 (688)	0.28 (677)

Tambak boyo	Average Shoreline Change(m/year)	11.09	12.20	0.34	15.28	36.28
	Average Retreats (m/year)	11.09	12.20	2.09	15.38	12.87
	Average length of shoreline retreats (m)	472.92	340.96	27.01	155.45	9.55
	Max retreat (m) (Transect no.)	676.14 (931)	463.67 (931)	96.52 (949)	222.9 (931)	42.7 (808)
	Min retreat (m) (Transect no.)	175.43 (808)	183.53 (808)	0 (911)	116.38 (924)	0.48 (911)
	Average advances (m/year)	0	0	1.67	1.47	40.35
	Average length of shoreline advances (m)	0	0	22.17	1.49	29.97
	Max advance (m) (Transect no.)	0	0	55.53 (850)	1.49 (808)	77.90 (839)
	Min advance (m) (Transect no.)	0	0	0.06 (897)	1.49 (808)	0.46 (921)
Bancar	Average Shoreline Change(m/year)	18.65	18.24	4.07	19.40	49.52
	Average Retreats (m/year)	18.65	18.24	4.27	19.60	60.41
	Average length of shoreline retreats (m)	795.49	509.85	55.54	198.19	47.70
	Max retreat (m) (Transect no.)	1006.4 (1101)	648.94 (1197)	161.16 (1106)	272.61 (1094)	262.63 (1087)
	Min retreat (m) (Transect no.)	360.37 (1088)	275.50 (1090)	0.11 (1211)	108.91 (1055)	1.25 (1180)
	Average advances (m/year)	0	0	4.31	110.85	28.19
	Average length of shoreline advances (m)	0	0	50.38	112.07	20.82
	Max advance (m) (Transect no.)	0	0	282.14 (1089)	138.68 (1087)	74.33 (1052)
	Min advance (m) (Transect no.)	0	0	6.66 (1087)	85.45 (1088)	0.19 (1030)
Total	Average Shoreline Change(EPR) (m/year)	15.24	14.55	3.42	17.45	30.56
	Average shoreline movement(NSM)(m)	650.11	406.69	44.27	17.6	22.69
	Max retreat(NSM) (m) (Transect no.)	1006.4	648.94	391.29	279.43	262.63
	Advance(NSM) (m) (Transect no.)	0.52	182.02	302.10	161.73	125.77

See Table 3 and Figure 6 for total shoreline changes from 1972 to 2015, indicating average shoreline retreat 15.23 m/year (EPR) and 13.86 m/year (LRR).

Table 3. Shoreline change for 1972-2015 (using 5 shorelines from different years)

Coast	Information	**Shoreline Change**							
		NSM (m)		SCE (m)		EPR (m/th)		LRR (m/th)	
Palang	MIN (Transect no.)	0.52	13	90.43	16	0.01	13	-0.75	12
	MAX (Transect no.)	965.73	183	965.73	183	22.64	183	20.85	183
	MEAN	618.62		628.94		14.51		13.00	
	SD					4.92		4.55	
Tuban	MIN (Transect no.)	598.68	265	598.68	265	14.04	265	12.23	265
	MAX (Transect no.)	911.28	201	911.28	201	21.37	201	19.12	201
	MEAN	756.00		756.00		17.73		15.98	
	SD					1.99		1.95	
Jenu	MIN (Transect no.)	140.35	620	140.35	620	3.29	620	2.35	620
	MAX (Transect no.)	946.88	375	946.88	375	22.20	375	20.13	375
	MEAN	614.43		618.10		14.41		13.07	
	SD					4.93		4.73	
Tambakboyo	MIN (Transect no.)	310.83	858	368.27	827	7.29	858	7.22	858
	MAX (Transect no.)	676.14	931	676.14	931	15.85	931	14.31	931
	MEAN	474.83		502.68		11.13		10.53	
	SD					2.17		1.81	
Bancar	MIN (Transect no.)	360.37	1088	424.90	1088	8.45	1088	7.49	1089
	MAX (Transect no.)	1006.40	1101	1006.40	1101	23.60	1101	21.25	1097
	MEAN	794.66		798.37		18.63		16.92	
	SD					2.58		2.36	
Total All Shores	MIN (Transect no.)	0.52	13	90.43	16	0.01	13	-0.75	12
	MAX (Transect no.)	1006.40	1101	1006.40	1101	23.60	1101	21.25	1097
	MEAN	649.69		657.15		15.23		13.86	
	SD					4.68		4.33	

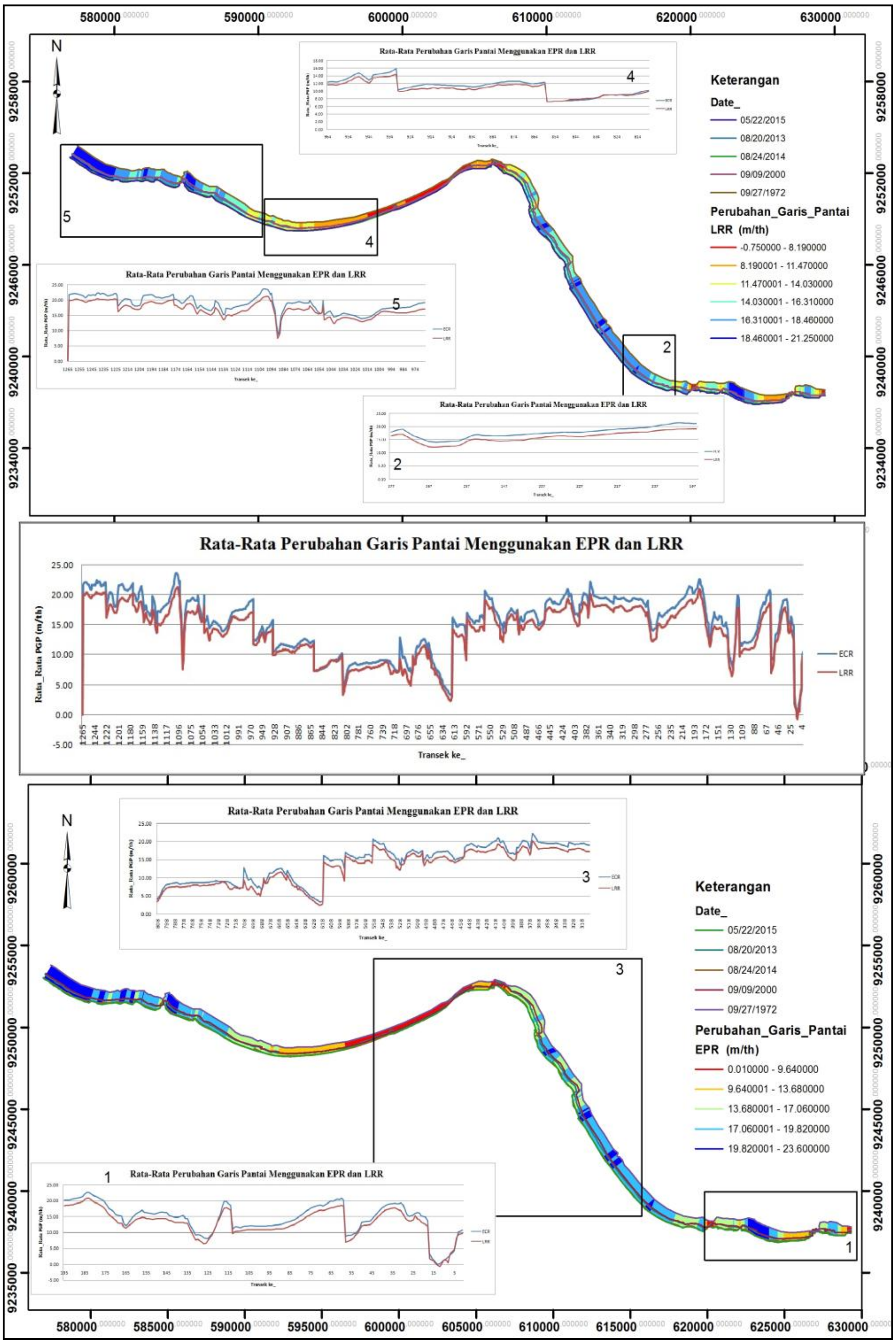

Figure 6. Average shoreline change (EPR and LRR in meters per year) for year 1972-2015

In this study, calculating the average of the changes by using DSAS it has taken into account the value of the uncertainty that occurs as the influence of the nature of the changes in shoreline position (wind, wave, tidal) and the uncertainty of measurement (eg, digitization and global positioning system error), by looking at the field of horizontal accuracy. While determining the direction of the baseline obtained from the tracking in the field by looking at the trend changes

CONCLUSION

Merge using two different coastlines in time shows the results of a more detailed and very clear so that it can be known with certainty at the transect line which indicates the coastline and shoreline retreat that combines advanced than 5 coastline. Using the DSAS to analyze changes in the shoreline can work well on a smaller area, see the location specific damage. But for the merger of two shoreline in this study, the rate of shoreline change using the Linear Regression Rate (LRR) can not be calculated, because the merger only use two lines are not used to observe trends that occurred but only to detect changes in the shoreline

ACKNOWLEDGEMENT

Authors thank Sepuluh Nopember Institute of Technology and Tuban PGRI Ronggolawe University.

REFERENCES

[1] Oyedotun, T.D.T., 2014. “Shoreline Geometry: DSAS as a Tool for Historical Trend Analysis British Society for Geomorphology”. Geomorphological Techniques, Chap. 3, Sec. 2.2

[2] Hapke ,C.J., Kratzmann, M.G., Himmelstoss, E.A., 2013. “Geomorphic and Human Influence on Large-Scale Coastal Change”. Geomorphology,199,160-170

[3] Rio LD, Gracia JF, and Benavente J. 2013. “Shoreline Change Patterns In Sandy Coasts. A case study in SW Spain”. Geomorphology, 196:252-266. DOI:10.1016/j.geomorph.2012.07.027

[4] Leyland J, Darby S E. 2008. “An Empirical -Conceptual Gully Evolution Model for Channelled Sea Cliffs”. Geomorphology, 102:419-434. DOI:10.1016/j.geomorph.2008.04.017

[5] Draut AE, Logan JB, Mastin MC. 2011. “Channel Evolution on The Dammed Elwha River”, Washington, USA. Geomorphology, 127:71-87. DOI:10.1016/j.geomorph.2010.12.008

[6] Katz O, Mushkin A. 2013. “Characteristics Of Sea-Cliff Erosion Induced By A Strong Winter Storm in the Eastern Mediterranean”. Quaternary Research, 80:20-32.DOI: 10.1016/j.yqres.2013.04.004

[7] Young AP, Flick RE , O’Reilly WC, Chadwicj DB, Crampton WC, Helly JJ. 2014. “Estimating Cliff Retreat ln Southern California Considering Sea Level Rise Using A Sand Balance Approach”. Marine Geology, 348:15-26.DOI: 10.1016/j.margeo.2013.11.007.

[8] Hackney C, Darby SE, Leyland J. 2013. “Modelling The Response Of Soft Cliffs to Climate Change: A Statistical, Process - Response Model Using Accumulated Excess Energy”. Geomorphology, 187:108-121. DOI:10.1016/j.geomorph.2013.01.005

[9] Thébaudeau B. Trenhaile AS, Edwards RJ. 2013. “Modelling the Development of Rocky Shoreline Profiles Along The Northern Coast of Ireland”. Geomorphology, 203. 66-78. DOl: 10.101 6/j.geomorph.201 3.03.027.

[10] Barman , N.K., Chatterjee, S., and Khan, A., 2015. “Trends of Shoreline Position: An Approach to Future Prediction for Balasore Shoreline,Odisha, India”. Open Journal of Marine Science, 2015, 5: 13-25

[11] Mageswaran ,T. , Ram, M. V. , Chenthamil, S.S. , Arumugam, T., Tune, U., and Kankara, R.S.,2015. “Assessment of Shoreline Changes Along Nagapattinam Coast Using Geospatial Techniques”. International Journal Of Geomatics And Geosciences. Volume 5, No 4: 555-563

[12] Chand, P., and Acharya, P., 2010. “Shoreline Changeand Sea Level Rise Along Coast of Bhitarkanika Wildlife Sanctuary, Orissa: an Analytical Approach of Remote Sensing and Statistical Techniques”. Int J Geom and Geosci, 1(3):436-455

[13] Natesan, U., Parthasarathy, A., Vishnunath, R., Kumar, G.E.J., and Ferrer,V.A. 2015. “Monitoring Longterm Shoreline Changes Along Tamil Nadu, India Using Geospatial Techniques “. International Conference On Water Resources, Coastal And Ocean Engineering (ICWRCOE 2015) Aquatic Procedia 4:325–332