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THE 1ST
WARMADEWA UNIVERSITY
INTERNATIONAL CONFERENCE ON
ARCHITECTURE AND CIVIL ENGINEERING

SUSTAINABILITY DESIGN AND CULTURE

DENPASAR, OCTOBER 20TH, 2017

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COASTLINE CHANGES ANALYSIS IN BULELENG REGENCY BY USING SATELLITE DATA

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ABSTRACT

The study of monitoring and analysis of coastline changes has been widely used satellite imagery. Satellite data that is often used in monitoring studies and analysis of coastline changes are Landsat, Quickbird, Allos dan IKONOS. The aim of study is to determine an average of coastline change in Buleleng regency by using two kind satellite are SPOT 5 in 2009 has a spatial resolution of 10 m (multispectral) and SPOT 6/7 in 2015 has a spatial resolution 1.5 m. This research contributes to local government and central government as a database in decision making for coastal area management. The result of analysis shows the average of coastline change in Buleleng Regency is 8.64 m.

Keywords: buleleng; coastline; satellite.

A. INTRODUCTION

The coastline is defined as the boundary between land and surface water. In the dynamic process there are several factors that influence the shoreline changes: hydrology, geology, climate and vegetation. Therefore it is necessary to update the map of shoreline change that is done continuously. This renewal is needed to find out the information on coastal resource management, coastal protection and also for sustainable development planning in the coastal area(Guariglia, et al., 2006).

Coastline mapping can be defined by direct field measurement, aerial photography analysis and remote sensing analysis by using satellite imagery (Guariglia, et al., 2006). Technological developments have led to the use of satellite imagery in coastline change analysis.

Satellite data were utilized for coastline change analysis in many researches. For example Kuleli, Guneroglu, Karsli, & Dihkan(2011) used multi-temporal Landsat images and Digital Shoreline Analysis System (DSAS) to analys shorelinechangealong the coastal Ramsar wetlands of Turkey. Landsat MMS, Landsat TM and SPOT-4 were utilised to estimate the spatio-temporal changes that occurred in the coastal zone between Damietta Nile branch and Port-Said between 1973 and 2007 (El-Asmar & Hereher, 2011). Landsat MSS image of 1979, Landsat TM and ETM+images of 1990 and 2000, SPOT image of 2003 and the topographic map 1:100,000 of 1966 and a nautical map scale 1:150,000 of 2003 were utilized to analysis coastline change detection of the Pearl River Estuary, China(Li & Damen, 2010). SPOT image was used to evaluate shoreline in Progreso, Yucatán, México(Rubio, Huntley, & Russell, 2015). Landsat imagery between 2000 and 2014 were utilized to evaluate of annual mean shoreline position at El Saler Valencia, Spain (Caballer, García, Pascual, Beser, & Vázquez, 2016). Combination aerial photographs and sattelite imagery (IKONOS, Quickbird, Worldview2 and Geoeye-1) were used to interpreted shoreline change at Wotje Atoll, Marshall Islands (Ford, 2013). Aryastana, Eryani, & Candrayana (2016) were used SPOT 5 and SPOT 6/7 to analysis the averege of coastline changes and average of erosion rate from 2009 and 2015 at Gianyar Regency, Bali Province, Indonesia. Post-processing result of Envisat satellite altimetry data was evaluated in this study to generate precise sea level height and sea level rise as the bases for the coastal area potential flood mapping, with case study of Buleleng Regency, Bali, Indonesia. In the post-processing stage, three types of geophysical corrections that greatly affect the accuracy of altimetry data in coastal areas were used, namely: tide, tropospheric and ionospheric corrections (Heliani, Putra, & Subaryono, 2014).

The use of remote sensing imagery such as Landsat and Geographic Information System (GIS) plays a very important role as a cheap and easy method of provide data on coastal area coverage and dynamics therein(Kasim, 2012).The objective of this research is to analysis the average of coastline changes in Buleleng Regency based on SPOT 5 and SPOT 6/7 image.

B. STUDY AREA

The research sites were conducted along the coast in Buleleng Regency (Figure 1). Buleleng Regency is located in the northern part of Bali, geographically located at 8º03’40”-8º23’00” LS and 114º25’55”-115º27’28” BT. It has a coastal length of about 144 km stretching from west to the east of Bali island (BPS, 2015). It is the one of the regency in the Bali Province with the longest coastline.

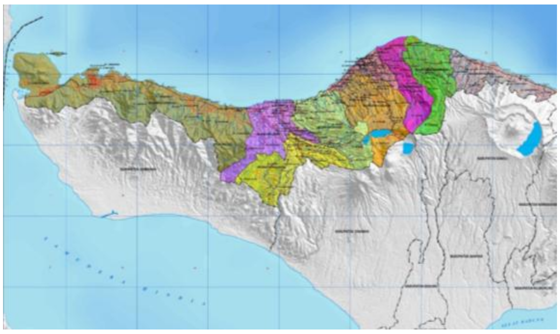


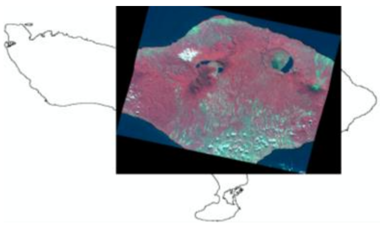
Figure 1. Study Area (Anonim, 2016)

C. DATA AND METHODS

1. Satellite Data

Satellite imagery wasutilized areSPOT 5 image in 2009 has a spatial resolution of 10 m (multispectral) and SPOT 6/7 image in 2015 with resolution up to 1.5 m, which in detail can be seen in Table 1.

Table 1. Image Data Specification

No	Satellite Imagery	Resolution (m)	Acquired Date	Image
1	SPOT 5	10	04/12/2009 time 02:32:45	
2	SPOT 5	10	06/14/2009 time 02:22:45	
3	SPOT 5	10	06/15/2008 time 02:20:59	
4	SPOT 6	1.5	03/19/2015 time 09:18:35	

No	Satellite Imagery	Resolution (m)	Acquired Date	Image
5	SPOT 6	1.5	02/16/2015 time 09:08:32	
6	SPOT 7	1.5	07/02/2015 time 09:11:00	

2. Image Processing

Image processing consists of image cropping, radiometric correction, geometric correction, band combination andcoastline digitization (Figure 2).

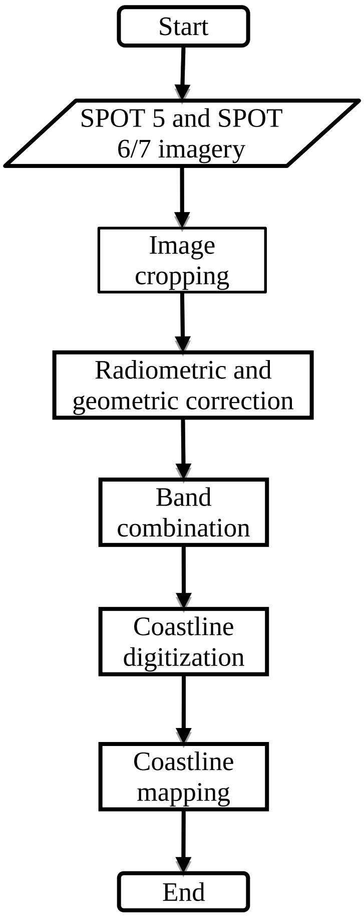


Figure 2. Flowchart of Image Processing

a. Image cropping

The image cropping was needed to get the Area of Interest (AOI). It aims to decrease the file size, so that the process will be fast comparing with image without cropping (Figure 3).

b. Radiometric correction

Radiometric correction of remotely sensed data normally involves the processing of digital images to improve the fidelity of the brightness value magnitudes. The main purpose for applying radiometric corrections is to reduce the influence of errors or inconsistencies in image brightness values that may limit one's ability to interpret or quantitatively process and analyze digital remotely sensed images (Stow, 2017). Raw data processed using ER-Mapper (Figure 4).

c. Geometric correction

Geometric corrections are made to correct the inconsistency between the location coordinates of the raw image data, and the actual location coordinates on the ground or base image. Several types of geometric corrections include system, precision, and terrain corrections. Geometric correction is necessary to preprocess remotely sensed data and remove geometric distortion (Dave, Joshi, & Srivastava, 2015).The actual coordinates on the ground were using Bench Mark (BM) spread in Buleleng Regency (Table 2).

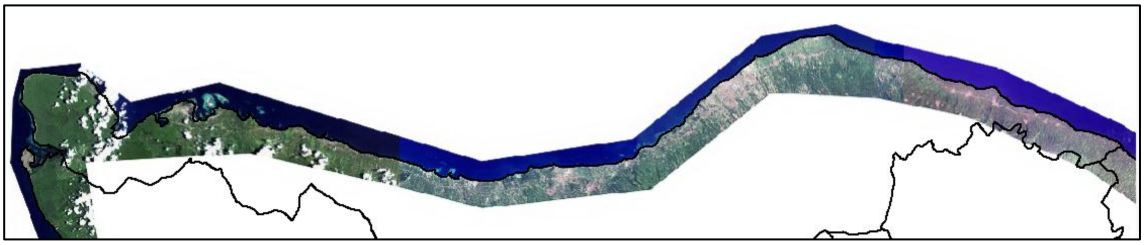


Figure 3. Result of Image Cropping

Figure 4. Result of Radiometric Correction

Table 2. BM Coordinates in Buleleng Regency

Coastal Area	BM Code	Coordinates		
		X	Y	Z
Gondol-Celukan Bawang	BM1-TK	246962.00	9098244.00	3.520
Gondol-Celukan Bawang	BM2-TK	247024.31	9098203.33	3.520
Gondol-Celukan Bawang	BM3-TK	248087.17	9097875.17	2.850
Gondol-Celukan Bawang	BM7-TK	251770.41	9096436.74	2.680
Gondol-Celukan Bawang	BM14-TK	258823.15	9094445.08	2.250
Celukan Bawang-Pengastulan	PCB-11	262629.88	9093707.97	3.626
Celukan Bawang-Pengastulan	PCB-06	267123.55	9093959.40	3.156
Celukan Bawang-Pengastulan	PCB-03	269437.04	9094875.98	2.289
Celukan Bawang-Pengastulan	PCB-01	271882.09	9095087.64	2.809
Kubutambahan	KT-1	302534.00	9107015.00	4.113
Kubutambahan	KT-3	300758.01	9107997.78	4.212
Kubutambahan	KT-4	299205.46	9108357.64	3.874
Kubutambahan	KT-6	296856.32	9108068.34	3.125
Seririt-Kaliasem	SKA-10	272938.98	9094830.69	3.487
Seririt-Kaliasem	SKA-7	276471.52	9095013.42	3.238
Seririt-Kaliasem	SKA-4	279407.63	9095623.57	2.611
Seririt-Kaliasem	SKA-1	282033.75	9097051.88	3.053
Tembok-Tianyar	BMT-1	330053.79	9096859.57	3.911
Tembok-Tianyar	BMT-3	331531.53	9095518.69	3.943
Tembok-Tianyar	BMT-5	333109.79	9095121.99	3.421
Tembok-Tianyar	BMT-7	335277.93	9093320.71	3.391
Tembok-Tianyar	BMT-11	337731.80	9091562.00	3.725
Kalisada	KS-6	265372.17	9093414.77	2.953
Kalisada	KS-1	267673.59	9094183.88	2.683

Source: Balai Wilayah Sungai Bali Penida

d. Band Combination

Multispectral data are composed of several different bandwidths of image data taken at the same time. Using these either alone or combined enables discrimination between many different cover and target types (Belliss, 2017). SPOT has two band combinations: RGB-123 and RGB-321. Band combination RGB-321 was utilized to process image data.

e. Coastline digitization

Coastline is obtained by manual digitization of image that has the MNDWI (Modified Normalized Difference Water Index) transformation process. Digitization process is done by using ArcGIS (Figure 5).

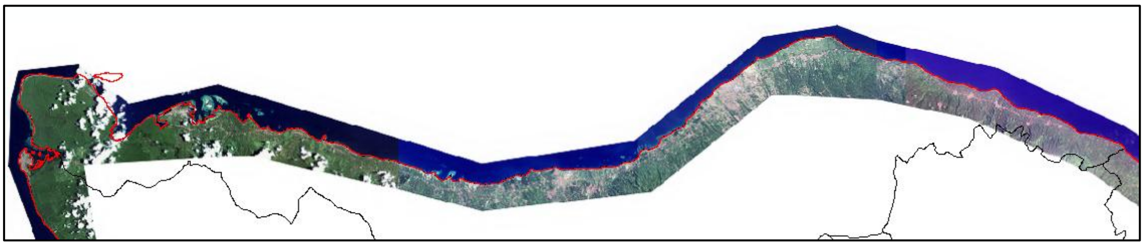


Figure 5. Coastline Digitization of SPOT Image of 2015

3. Waterline Correction

The 1985 national tidal height datum was used as the local tidal datum (h) that can be estimated from the hydrodynamic model. It was assumed that the beach moves offshore or onshore with the same bottom profile (Huang et al., 1994 in Liu, Huang, Qiu, & Fan, 2013). Thus, the waterlines were shifted to the tidal datum-based shoreline position based on the equiangular triangle theory. The shifting process and the bottom slope calculation were carried out by sectional calculation (Thieler et al., 2009 in Liu, Huang, Qiu, & Fan, 2013). The shifted distance, *Y*, was estimated by equation(Aryastana, Eryani, & Candrayana, 2016):

$$Y = \left(T_k - \left(\frac{T_k}{T_b} \times T_x\right) \times Tan\emptyset\right) \qquad (1)$$

Where:

Y : The shifted distance
T_k : Sectional HWL (High Water Level)
T_b : Benoa Harbor HWL
T_x : Tidal datum where the image was acquired
$Tan\emptyset$: coastal slope

The tidal datum was utilized to analysis the waterline shifting process is from Benoa harbor and the data when satellite was acquired time (Table 3). The sectional of coastal slope in Buleleng Regency can be seen in Figure 6.

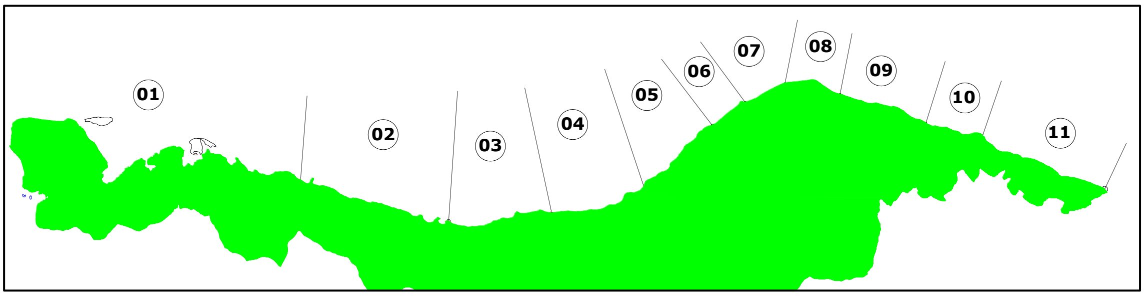


Figure 6. Sectional of Coastal Slope

Table 3. Section of Coastal Slope Value

Section	Slope	Section	Slope
01	1:20	07	1:12
02	1:23	08	1:12
03	1:18	09	1:11
04	1:27	10	1:11
05	1:20	11	1:13
06	1:13		

Source: Balai Wilayah Sungai Bali-Penida

Table 4. The Shifted Distance for Satellite Imageryof 2009

Section	Acquired Image Date	Acquired Image Time	T_k(m)	T_b(m)	T_x(m)	Slope	Y(m)
01	12-04-2009	02:32:45	2.2	2.6	1.4	20	20.31
02	12-04-2009	02:32:45	2.2	2.6	1.4	23	23.35
03	12-04-2009	02:32:45	2.2	2.6	1.4	18	18.28
04	12-04-2009	02:32:45	2.2	2.6	1.4	27	27.42
05	14-06-2009	02:22:45	2.2	2.6	1.9	20	11.85
06	14-06-2009	02:22:45	2.2	2.6	1.9	13	7.70
07	14-06-2009	02:22:45	2.2	2.6	1.9	12	7.11
08	14-06-2009	02:22:45	2.2	2.6	1.9	12	7.11
09	14-06-2009	02:22:45	2.2	2.6	1.9	11	6.52
10	14-06-2009	02:22:45	2.2	2.6	1.9	11	6.52
11	14-06-2009	02:22:45	2.2	2.6	1.9	13	7.70

Table 5. The Shifted Distance for Satellite Imagery of 2015

Section	Acquired Image Date	Acquired Image Time	T_k (m)	T_b (m)	T_x (m)	Slope	Y (m)
01	03-02-2015	09:09:27	2.2	2.6	1.7	20	15.23
02	03-02-2015	09:09:27	2.2	2.6	1.7	23	17.52
03	02-07-2015	09:11:00	2.2	2.6	2.4	18	3.05
04	02-07-2015	09:11:00	2.2	2.6	2.4	27	4.57
05	02-07-2015	09:11:00	2.2	2.6	2.4	20	3.38
06	02-07-2015	09:11:00	2.2	2.6	2.4	13	2.20
07	02-07-2015	09:11:00	2.2	2.6	2.4	12	2.03
08	02-07-2015	09:11:00	2.2	2.6	2.4	12	2.03
09	19-03-2015	09:18:35	2.2	2.6	2.1	11	4.65
10	19-03-2015	09:18:35	2.2	2.6	2.1	11	4.65
11	19-03-2015	09:18:35	2.2	2.6	2.1	13	5.50

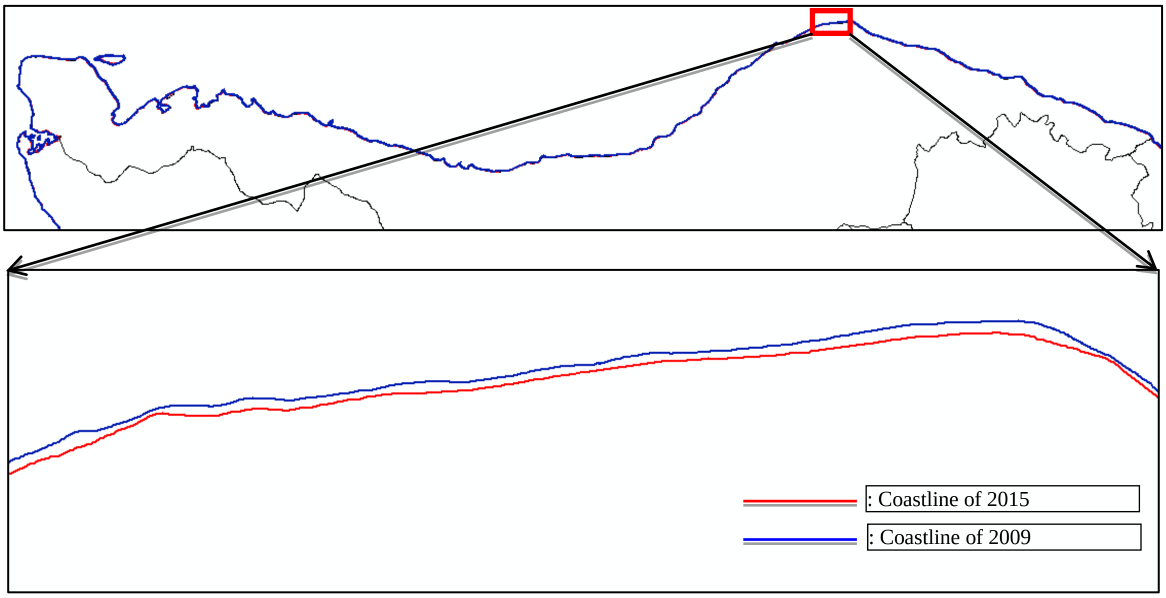


Figure 7. Coastline Map of 2009 and 2015

4. Coastline Changes Analysis

Coastline changes analysis was calculated based on overlapping method from 2009 and 2015 (Figure 6). Based on Figure 6, the length of coastline changes is indicated by A, B, C, D and E. The average of coastline changes (CR) in one area of coastal was estimated by:

$$CR = (A+B+C+D+E)/5 \quad (2)$$

Based on data from public work office, Buleleng Regency has 52 coastal areas stretching from west to the east of Bali islands. The average of coastal changes in each area can be seen on Table 6.

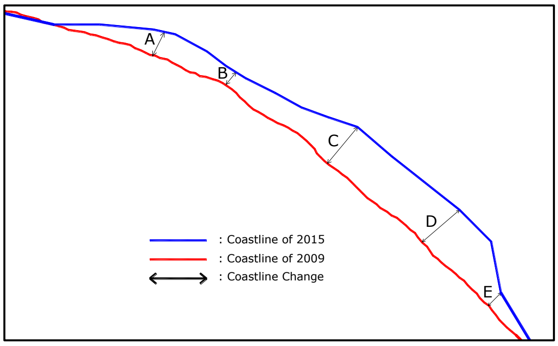


Figure 8. Coastline Changes Analysis Method

Table 6. The Average Coastline Change in Buleleng Regency

No	Coastal Area	Coastline Changes (m)
1	Sumber Kelampok (-Menjangan)	4.74
2	Pejarakan	2.13
3	Sumberkima	1.98
4	Pemuteran-Pulaki	3.05
5	Pulaki-Banyupoh	7.90
6	Gondol-Penyabangan	3.38
7	Musi	3.89
8	Sanggalangit	2.88
9	Gerokgak	9.08
10	Patas	6.35
11	Pengulon	5.58
12	Celukan Bawang	6.20
13	Kalisada	9.29
14	Banjar Asem	7.42
15	Umeanyar	11.13
16	Lokapaksa	6.73
17	Pengastulan	11.85
18	Seririt	7.14
19	Sulanyah	7.19
20	Tangguwisia	8.80
21	Kalianget	7.61
22	Banjar	8.24
23	Dencarik	8.36
24	Temukus	6.34
25	Kaliasem	7.07
26	Kalibubuk	11.61
27	Anturan	9.79
28	Tukadmungga	12.42
29	Pemaron	8.79
30	Bhaktisegara	8.55
31	Banyuasri	8.04
32	Kaliuntu	6.06
33	Kampung Anyar	7.68
34	Kampung Bugis	11.89
35	Kampung Baru	6.61
36	Banyuning	6.62
37	Penarukan	9.36
38	Kerobokan	8.30
39	Sangsit	10.19
40	Bungkulan	13.56
41	Kubutambahan	16.11
42	Bukti	15.38
43	Pacung (Alasari)	13.91
44	Sembiran	12.19
45	Pacung	7.76
46	Julah	6.22
47	Bondalem	10.59
48	Tejakula	15.73
49	Les	9.89
50	Penukutan	7.22
51	Sambirenteng	9.29
52	Tembok	11.88
Average		**8.46**

D. RESULTS AND DISCUSSION

Coastline changes occurred in Buleleng regency based on SPOT satellite imagery in 2009 and 2015. The average coastline changes in Buleleng Regency are 8.46 m (Table 6). The entire coastal area in Buleleng Regencyhas changed coastline. The highest coastline changes occur in Kubutambahan coastal area which is 16.11 m, while the smallest change occurred in Sumerkima coastal area which is 1.98 m.

The results of this study demonstrate that coastal movement (erosion) has caused coastline changes at the Buleleng Regency. In Buleleng Regency there is no scientific research on coastal inventory and coastline changes analysis that includes all coasts of Buleleng Regency.

E. CONCLUSION

The coastlines processingby using satellite images in 2009 and2015 were overlaid to establish the average of coastline changes in Buleleng Regency. The average coastline changes in Buleleng Regency are 8.46 m.

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