COASTAL CHANGES ASSESSMENT USING MULTI SPATIO-TEMPORAL DATA FOR COASTAL SPATIAL PLANNING PARANGTRITIS BEACH YOGYAKARTA INDONESIA

Muhammad Sigit Pujotomo

February 2009

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Thesis submitted to the Double Degree M.Sc. Programme, Gadjah Mada University and International Institute for Geo-Information Science and Earth Observation in partial fulfillment of the requirement for the degree of Master of Science in Geo-Information for Spatial Planning and Risk Management

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THESIS

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DISCLAIMER

This document describes work undertaken as part of a study at the Double Degree International Program of Geo-information for Spatial Planning and Risk Management, a Joint Education Program of UGM, Indonesia and ITC, The Netherlands. All view and opinion expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the institute.

Yogyakarta, February 2009

Author

ABSTRACT

Coastal zone, the interface of land and sea, is the most inhabited area and favorable place to undertake development activities. Coastal area also very dynamic and constantly changing. Changes in the coast of Indonesia consist of short term, medium term and long term changes that can be seen as various kind of natural hazards, gradual or intermittent advance or retreat shoreline and those such as land uplift of subsidence or sea level rise and fall.

This study is oriented to have better understanding of the south coast characteristic particularly in Parangtritis beach, emphasizing on shoreline and land-use changes using multi spatio-temporal data by taking advantages of Geographic Information System (GIS). Spatio temporal data used consist of topographic maps, aerial photograph, Quickbird Image and field measurement. Shoreline change rate assessed using Linear Regression Method and conducted using the advantage of Digital Shoreline Analysis System.

The multi spatio data can be used to monitor and assess the coastal changes by taking advantages of GIS with regard to scale differences. High resolution image such as Quickbird image can be use to dealing with scale difference by using it to plot the delineation from another spatial data sources due to it's high resolution.

The shoreline changes assessment shows that coastal processes in Parangtritis beach is accretion in the magnitude of 1.70 m/y on average. Area affected by accretion process is beach preservation zone in which at the eastern part is corresponding to anthropogenic activities such as tourism, and in the western part is corresponding to inlet/river mouth.

Prediction of shoreline position is conducted by extrapolating change rate into year 2018 and 2058. Result shows that shoreline positions are likely on average to be 20 m and 100 m or less seaward from the recent shoreline.

Landuse changes assessment shows that built up area increase very significant during 1992 to 2003 in the rate of 3.2 ha/year. The increase of built up area was along with the decreasing of barren land from 1 ha/year during 1920-1992 to 5.8 ha/year during 1992-2003. Barren land class such as sand dune is the most utilized area in Parangtritis, might be due to the tourism development.

The most rapid landuse changes in Parangtritis is built up class. This is due to the tourism activities. The most affected landuse class by tourism activities in Parangtritis is barren land, particularly sand dune class. Rice field changed but not significant, showed the importance of agriculture for Parangtritis residents.

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1. INTRODUCTION.

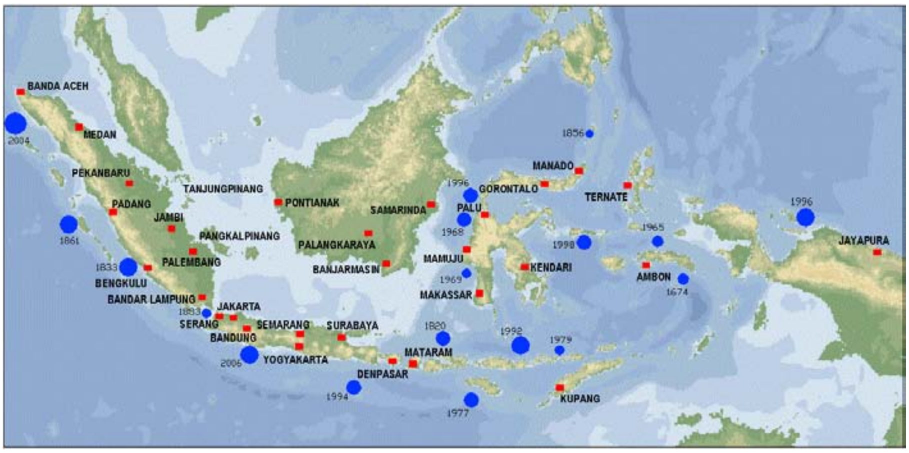
1.1. Background

The coastal zone is the interface of land and sea and also the most inhabited area and favorable place to undertake development activities. It is driven by 3 economic rationalities i.e.: 1) natural resources such as fisheries, mangroves and coral reef; 2) accessibilities for residential, industrial and other development activities; 3) aesthetical value such as beach and views (Dahuri 1998). In Indonesia, 42 municipalities and 181 regencies are situated in the coastal area, while 60% of Indonesian people living within 50 km of shoreline (2003).

Coastal area also very dynamic and constantly changing. Bird (Bird *et al.* 1980) indicated that changes in the coast of Indonesia are consist of short term, medium term and long term nature. Short term changes can be caused by various kinds of natural hazards (earthquake, volcanic eruption, tsunami and river flooding). Medium term changes can cause gradual or intermittent advance or retreat of the shoreline and long term changes can be caused by land uplift or subsidence (neo-tectonic activity) or sea level rise and fall.

Considering natural hazards that drive short term changes in the coast of Indonesia, Java Island due to tectonic setting is very vulnerable to natural hazard such as earthquake, tsunami and volcanic eruption. In the year of 2006, an earthquake has triggered tsunami in the southern part of West Java and propagate to the east. As the result, the southern part of coastal zone in Java was affected by tsunami (Giyanto 2007).

If we are dealing with short time changes, people should be aware in term of planning and development and take proper mitigation measures. Medium term changes cause to advance and retreat the shoreline, must be acknowledged and countered by practical measures.



Source: www.pu.go.id

Figure 1. Earthquake Location In Indonesia That Generate Tsunami Up To Year 2006

Table 1. Tsunami Record In Indonesia

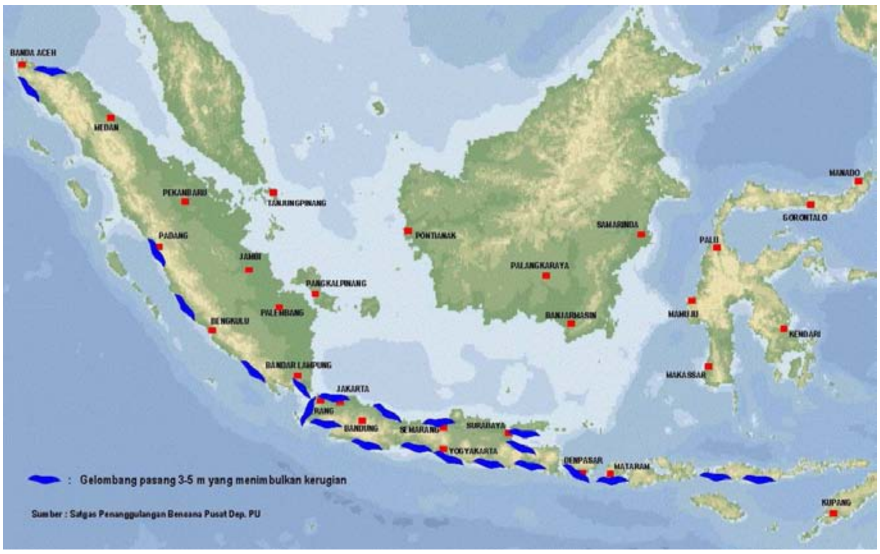
No.	Year	Location	Magnitude	Casualties
1.	1833	Sumbar, Bengkulu, Lampung	8,8	No record
2.	1883	G.Krakatau	-	36.000
3.	1938	Kep. Kai - Banda	8,5	No record
4.	1967	Tinambung	-	58
5.	1968	Tambu, Sulteng	6	200
6.	1977	Sumbawa	6,1	161
7.	1992	Flores	6,8	2.080
8.	1994	Banyuwangi	7,2	377
9.	1996	Toli - toli	7	9
10.	1996	Biak	8,2	166
11.	2000	Banggai	7,3	50
12.	2004	Nanggroe Aceh Darussalam	9	250.000
13	2006	Sukabumi, Pangandaran	6.8	130

Source: www.pu.go.id

Shoreline change is considered one of the most dynamic processes in coastal areas and can significantly affect human activities. Accretion could lead to silting and closure of ports, while erosion due to coastal currents may lead to loss of land and properties. Dense population in many coastal areas in the developing countries creates the more vulnerable areas. It is apparent that mapping the shoreline changes has become important as an input data for coastal hazard assessment (Frihy et al. 1994) (Marfai et al. 2007).

Bird (1980) stated that there are five primary factors that may change shoreline position : a) wave and current processes, b) sea level changes, c) sediment supply, d) coastal geology and morphology, and 5) human intervention.

Parangtritis beach is directly facing the Indian ocean and therefore effected by high energy waves that significantly influence the coastal dynamics. Wave energy, beside causing abrasion, is also generating long shore current which are causing sedimentation in certain area. (Bird et al. 1980). Although subjected by high energy waves which normally causing erosion, for decades Parangtritis beach has been supplied with sediment from the Merapi Volcano trough two main channels i.e.: Progo River and Opak River. Nevertheless, the construction of the sabo dam and also sand mining activity has been reducing the sediment supply to the south coast of Yogyakarta (Sumaryono et al. 2000).



Source:http://www.pu.go.id

Figure 2. Area Subjected By High Wave 3 – 5 M In Indonesia On 18 May 2007

Table 2. Casualties And Damages Caused By High Wave On 18 May 2007

No	Regency	Wave Height	Casualties	Damages
1	Sukabumi	3 m	No casualties 361 abandoned	61 houses collapsed, hundreds damaged, 300 units shops heavily damaged
2	Garut	5 m	2 injured, 1.034 abandoned	6 houses and 15 boats heavily damaged, 199 houses inundated.
3	Kebumen, Cilacap	5-7 m	No casualties reported	11 boats totally damaged, 6 boats heavily damaged, 31 boats, Hundreds fishing nets lost
4	Kulon Progo, Bantul, Gunung Kidul	4 m	No casualties reported	14 houses, 16 shops, 1 fishing auction, 22 boats damaged 1.020 fishing nets lost
5	Pacitan	3 m	No casualties reported	1 house, 1 ware house, 1 auction place and 40 boats damaged

Source : www.pu.go.id

The movement of the shoreline position due to accretion or erosion is a great concern in coastal zone management. Morton (1979) after Moran (2003) stated that mapping shoreline changes and predicting future shoreline positions have to be an important scientific and coastal management objectives. Therefore the accurate measures of the historic shoreline position and prediction of future locations are essential for coastal planning and management.

1.2. Problem Statement

Parangtritis beach is situated in the southern part of Yogyakarta Special Province, and under the authority of the government of Bantul Regency. As a tourist destination, Parangtritis beach has developed as an economic growth center together with other tourist destinations along the south coast of Yogyakarta i.e.: Samas, Trisik, and Pandansari beaches. As a potential economically growing area, Parangtritis has attracted over time more and more people to reside and has a good living condition. As a consequence, the growing number of people needs more space and starts to utilize the coast which creating vulnerable area from coastal hazard despite the buffer zone of 200 m according to spatial planning has been established.

On the other hand, recently the south coast of Java has been suffered from geologic and climatologic events such as a tsunami in 17 July 2006 and storm waves and tidal waves during 18 – 19 May 2007 (see Table 2.) d during January, Pebruary and March 2008 (Sunarto 2008). It was also reported that erosion has been occurring in some parts of Yogyakarta's south coast such as Samas and Parangtritis beaches (Daru Waskita Trijaya 2008) ((R-3/Can)-n 2008) (Anonymous 2008). Those natural phenomena were reported to cause damages to many infrastructures such as fisheries facilities, tourist and resident properties near the shore.

The government of Bantul Regency has been taking serious measures to avoid any further damages by relocating infrastructures landward from the shoreline and banning any types of construction within 300 m line from the high water line. As a long term measures, there will be a plantation of Cemara Udang (*Casuarina equisetifolia*) on the beach, conserving sand dunes and rearranged on coastal landuse. However, there was a question about how far the line should ideally be established since that information regarding south coast characteristic is not known yet (WER 2006) (Anonymous 2008) (Lai 2008).

Establishment of a buffer zone is one of several effort commonly taken to reduce risk in the framework of coastal disaster risk management. Another schemes are accommodation and protection (Kay et al. 1999). Coastal hazard risk management requires the understanding of shoreline dynamic and should also consider potential future hazard such as enhanced sea level rise due to future global warming.

Monitoring coastal changes over time needs a complete spatio-temporal data set, which is difficult to find in Indonesia. The integration of multi source spatial and temporal data such as topographic maps and satellite imageries is considered to overcome the lack of data series availability (Marfai et al. 2007).

The study is focused on an understanding of the Java South Coast characteristic particularly in Parangtritis beach, emphasizing shoreline and land-use changes using multi spatio-temporal data by taking advantages of Geographic Information System (GIS).

1.3. Research Objectives

1.3.1 General Objective

To assess coastal changes in Parangtritis, Yogyakarta by mean of Geographic Information System (GIS) using multi spatio-temporal geographic data in order to provide information for coastal spatial planning.

1.3.2 Specific Objectives

To investigate shoreline changes in between 1870, 1920, 1976, 1992, 2003 and 2008 using multi spatio-temporal geographic data;

To investigate landuse changes in between 1920, 1992 and 2003 in relation to coastal spatial planning;

To define areas affected by shoreline changes.

1.3.3 Research Questions

No	Specific Objectives	Research Questions
1.	To investigate shoreline changes in between 1870, 1920, 1976, 1992, 2003 and 2008 using multi source spatio-temporal geographic data	- How to combine old topographic maps, aerial photographs and Quickbird image derived from Google Earth? - How to delineate shoreline from topographic maps? - How to delineate shoreline from aerial photographs and Quickbird images? - How to determine tidal situation in aerial photographs and Quickbird image? - How to generate shoreline from high resolution DEM? - How to compare shorelines position extracted from various type of spatio-temporal data ? - How to deal with scale and resolution difference?
2.	To investigate landuse changes in between 1920, 1992 and 2003 in relation to coastal spatial planning	- How to develop landuse classes that suitable for different type of multi spatio temporal data? - How to trace landuse changes in between 1920, 1992 and 2003?
3.	To define areas affected by shoreline changes	- Where is the area which are 1) trend to gain land due to accretion; 2) trend to loss land due to erosion - What is the effect of shoreline changes on present 200 m and 300 m buffer zone?

2. METHODOLOGY

2.1. Proposed Approach

Spc Obj	Research Questions	Approach	Expected Output
1	How to combine old topographic maps, aerial photographs and Quickbird image derived from Google Earth?	For topographic maps : georefenced using its original projection system and transformed into UTM zone 49S projection system and WGS84 datum. For aerial photographs and Quickbird image: georeferenced in UTM zone 49 S projection system and WGS84 datum using ground control points derived from field measurement	All data have a same coordinate system
	How to generate shoreline from topographic maps?	Delineate shoreline based on map data extraction (line tracing).	Shoreline feature represent MHW level
	How to determine tidal situation during the acquisition time of aerial photographs and Quickbird image?	Determine tide level during aerial photographs and Quickbird image’s time of acquisition from nearest tide gauge station (tide level calibration based on tide data).	Tide level information that are used for correcting shoreline position derived from aerial photograph and Quickbird image

Continuation.

Spc Obj	Research Questions	Approach	Expected Output
1	How to delineate shoreline from aerial photographs and Quickbird images?	Using dry-wet line as proxy of MHW, obtained by using visual interpretation method	Shoreline feature represent MHW level
	How to generate shoreline from high resolution DEM ?	Intersect high resolution DEM with MHW level derived from observed tide data from nearest tide gauge station.	
	How to compare shoreline from various type of spatio-temporal data ?	Transform all shoreline vertical datum into local mean high water usually used in topographic maps.	Shoreline with the same vertical datum
	How to deal with scale and resolution differences?	During on screen digitations, common scale taken to avoid differences on detail. This involved the generalisation of shoreline feature derived from images.	Shoreline feature with same degree of detail.
2	How to develop landuse classes that suitable for different type of multi spatio temporal data? (topographic maps, aerial photograps and Quickbird image)	Develop landuse classes vary from general to detailed one to accommodate the difference in the spatio-temporal data set.	Classification scheme that accommodate all landuse classes derived from each spatio temporal data set.
	How to trace landuse changes in between 1920, 1992 and 2003?	Overlay landuse map of 1920 with 1992 and 1992 with 2003	Landuse maps

Continuation

Spc Obj	Research Questions	Approach	Expected Output
3	Where is the area which are 1) gain land due to accretion? 2) loss land due to erosion?	Determining changes among dataset quantitatively and spatially. Extrapolate the change trend for 10 and 50 years to predict shoreline position and overlaid them on the existing landuse map and identify the possible affected infrastructure (structure and function).	Map of areas affected by shoreline changes
	What is the effect of shoreline changes on 200 m and 300 m buffer zone?		

2.2. Shoreline Changes Working Procedures

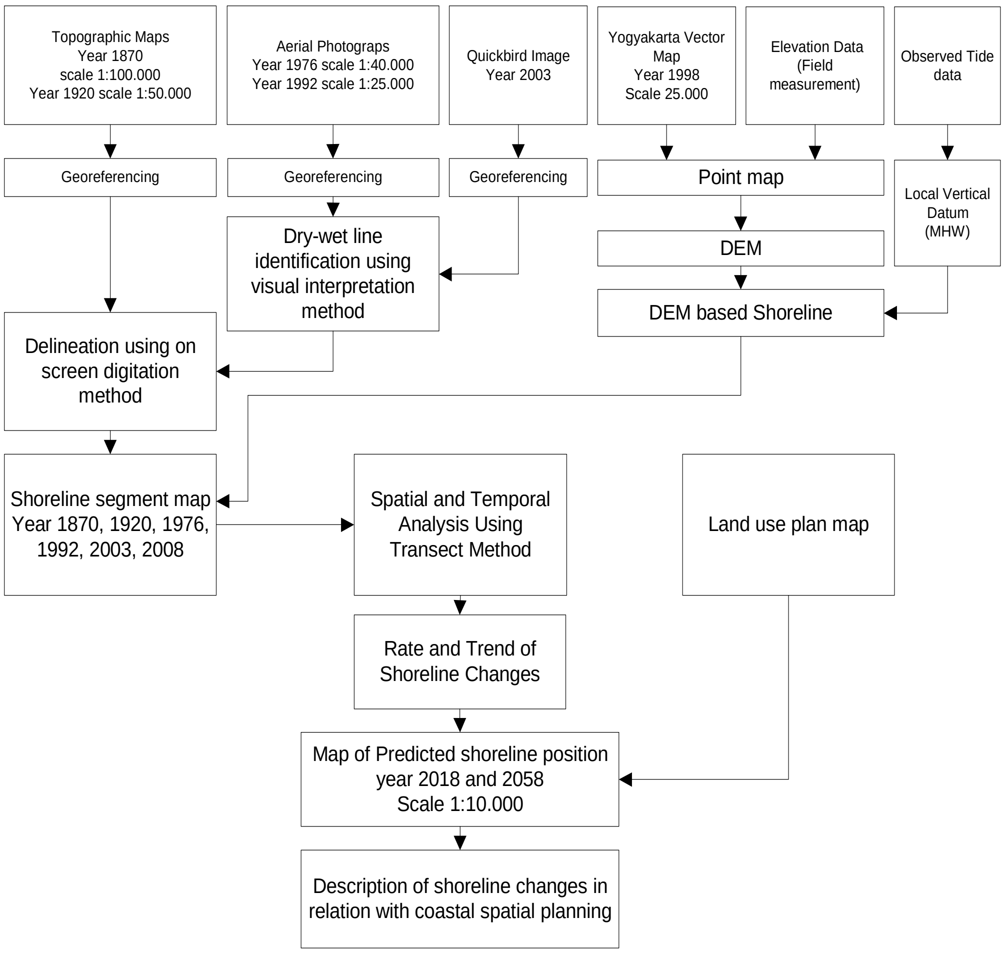


Figure 3. Flowchart of Shoreline Changes Assessment

2.3. Landuse Changes Working Procedure

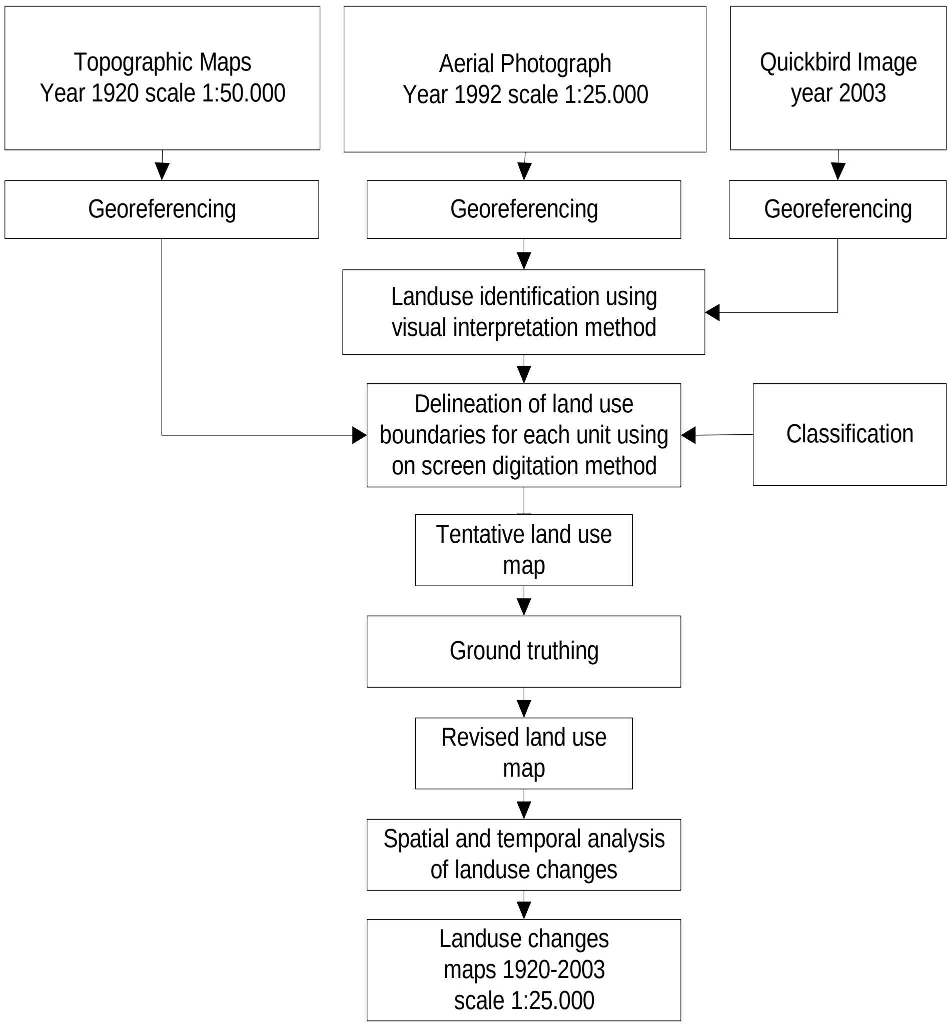


Figure 4. Flowchart of Landuse Changes Assessment

2.4. Data Availability

Referring to Figure 3, data used comprises of historical / archive spatial data namely topographic maps and aerial photographs of the study area, primary data which were derived from field measurement i.e.: elevation points and MWL shoreline segment and secondary data such as Predicted Tide Table and Landuse Plan Map. Secondary data were obtained from related institution i.e.: National Coordinating Agency for Survey and Mapping (Bakosurtanal) and local government of Bantul Regency. Detailed data used along with their description and intended usage are resumed in Table 3.

Software used comprise of image processing and GIS software. Image processing software used was Photoshop CS, while GIS software were:

ILWIS Academic 3.3

ENVI 4.3

ArcGIS 9.x

ArcView GIS 3.3

Global Mapper 8

Digital Shoreline Analysis System ver. 2.1.1 (DSAS) extension for ArcView.

Equipment used was Differential Global Positioning System (DGPS) Trimble GeoXT. Differential correction was conducted in the office known as post processing method.

DSAS is the application extension which is intended to extend the normal functionality of the ArcView geographic information system to include historic shoreline change analysis. The extension is aimed to guide a user conducting main steps in change analysis.

There are three main components of DSAS which assist user in change analysis i.e.: establishing baseline, constructing orthogonal transect at user specific and calculating rate of change.

As input, DSAS needs segments represent baseline and historical shoreline to which change analysis will be conducted. As the output, DSAS produces transects, intersection points and changes along a particular transect in database (dbf) file form. (Thieler *et al.* 2003).

Table 3. Data Used

No	Data type	Description	Source	Usage
1	Topographic map Year : 1870	Comprising of 4 sheets Scale 1:100.000 No projection data	Royal Tropical Institute –The Netherlands provided by ITC	Use for shoreline changes assessment
2	Topographic map Year : 1920	Scale 1:50.000 Comprising of 3 sheets : 1) Sheet 47/XLII-C and 47/XLIII-A, 2) Sheet 47/XLII-D 3) Sheet 47/XLIII-B Lambert Conformal Conic Projection	Royal Tropical Institute –The Netherlands provided by ITC	Use for shoreline changes and landuse changes assessment
3	Aerial photos (B/W, stereo pair) Year : 1976	Scale 1:40.000 Time of acquisition : Date: n/a Hour : 08.48 Local Time	PUSPIC UGM	Use for shoreline extraction
4	Aerial photos (B/W, stereo pair) Year : 1992	Scale 1:25.000 Time of acquisition : 8 November 1992 Hour :12.07 Local Time	PUSPIC UGM	Use for shoreline changes and landuse changes assessment
5	Yogyakarta Province vector map Year 1998	1st edition Scale : 1:25.000	Bakosurtanal	Use for DEM generation
6	Quickbird image of study area	Time of acquisition : 11 July 2003 Hour 10.30 Local Time	Downloaded from Google Earth	Use for shoreline changes and landuse changes assessment

No	Data type	Description	Source	Usage
7	Elevation points in intertidal zone	Field measurement along the beach, covered area from the top of foredune to most seaward available during low tide	Field measurement	Use for DEM generation
	MHW Shoreline	Shoreline segment represent Mean Sea Level digitized along the beach using DGPS through GPS tracking method	Field measurement	Use for determining DEM-based shoreline
8	Observed Tidal Data	Comprises of measured water level using three different sensors.	Sadeng Tide gauge station Gunung Kidul, Yogyakarta	Use for obtaining tidal datum for the study area
9	Predicted Tide Table	Year 2008	Bakosurtanal	Obtaining approximate time to acquisition of MWL shoreline
10	Coastal Spatial Planning Document	Semi detail and detail level of spatial planning documents	Bantul Regency Development Planning Board Bantul Regency Culture and Tourism Service	Use for analyzing the effect of shoreline changes on buffer zone and coastal spatial planning

3. STUDY AREA

3.1. Physical Setting

Parangtritis Village is located in Bantul Regency, Yogyakarta Special Region, Indonesia. Bantul Regency is one of five regencies/municipality in Yogyakarta Special Region and lies between 07º44′04″-08º00′27″ S and 110º12′34″-110º31′98″ E. While in the north, east and west Bantul Region is bordered by adjacent regencies, in the south, Bantul is bordered by Indian Ocean.

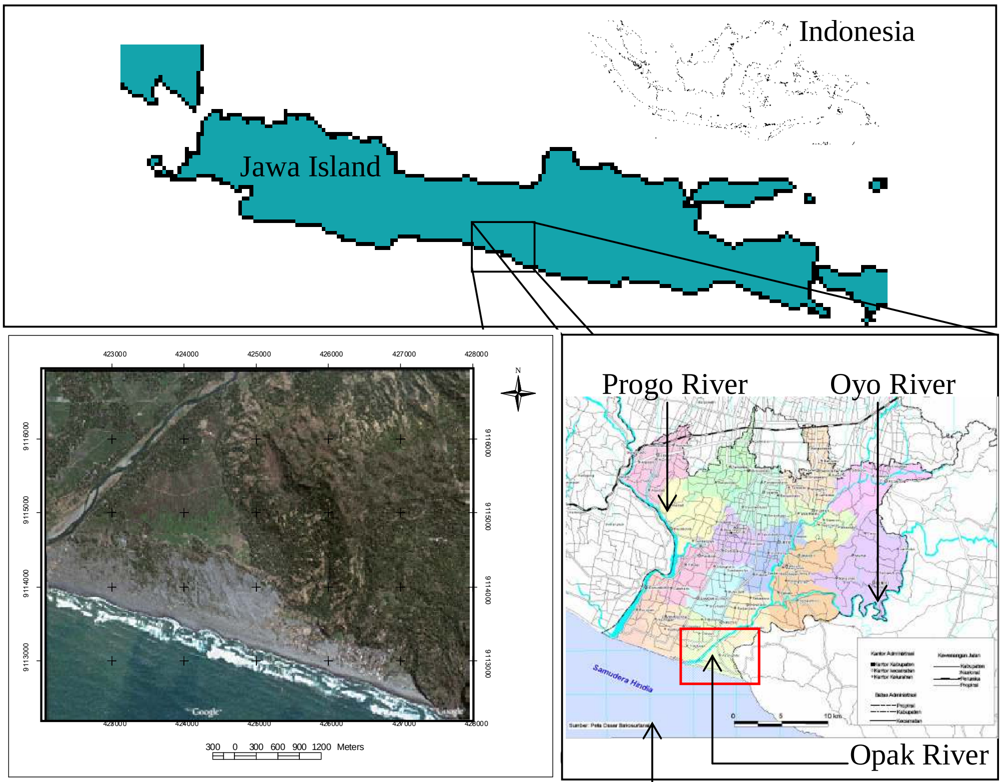


Figure 5. The Study Area

Three main rivers which flow through Bantul Regency are named : Progo, Oyo and Opak rivers. Oyo River, in the downstream merges with Opak River. The average discharge at the Progo outlet is 150 m^3/s and has constant discharge, while Opak River is intermittent river which mean its discharge is very much seasonal. Both rivers are often flooding its banks, especially during the rainy season (Badan Pengendalian Dampak Lingkungan 2005). Opak River flooding is recurrently caused by the closed of the river mouth. During dry season, when the discharge is minimum, river mouth often clogged by sediment due to wave activity. As a consequence, when the discharge rises in the wet season, flooding occurs.

3.1.1 Topography of the Study Area

Bantul region's elevation is between 0 - 400 m above mean sea level. The highest elevation is in the Baturagung mountains on which Bantul's eastern borders sites. The slope of Bantul Basin (Graben Bantul) is dominated by slope class of 0-2% and a small part of the region has slope of 8 -15 % which is in the Menoreh limestone mountain on the west, and slope class of 25 - 40% is located on the eastern part (Giyanto 2007).

In Parangtritis village, the elevation of 0 – 35 m can be found especially in the southern part which bordered directly by the Indian Ocean. Northeast, one finds hills with the elevation reaches 350 m and 175 m on average (Hara 2007).

Most of the beach topography is almost flat, especially in the eastern part near the cliff, and gradually steeper toward the west near the Opak River. Landward of the beach, one finds large areas with sand dune of several types such as barchan and longitudinal dunes. (Sutikno et al. 1988).

3.1.2 Geology

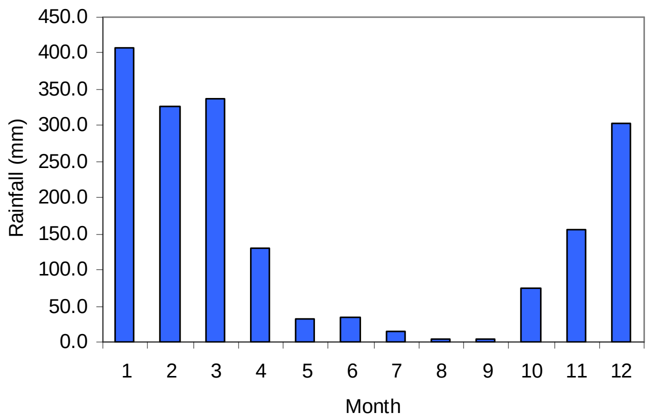
The geological formation in Bantul region are formed by recent sedimentation of Merapi Volcano on the middle part (Graben Bantul), and several smaller parts in the form of Sentolo formation hill on the western part, Aluvium formation, Andecite (Baturagung), Semilir formation, Kepek, and Nglangran on its eastern part. Physiographically, the landscape consist of the Merapi fluvio-volcanic plain, the Baturagung Mountain Range, the Sentolo Hills Range, Progo River plain and the shore plain.

3.1.3 The Climate of Bantul Region

Climate classification in the study area is derived from Barongan Climate Station rainfall data. Following Schmidth-Ferguson classification climate and based on 20 years period (1986-2006) rainfall data, Bantul Region has Q value of 105.17%. This means that climate in Bantul region is classified as E (fairly dry climate).

Q value is ratio between dry months and wet months. Dry months are considered to have less than 60 mm rainfall while wet months have more than 100 mm. Schmidth-Ferguson classification required rainfall data for at least 10 year observation.

Wet months start from November – April and the dry months from May – September as can be seen in Figure 6. The month of April and May are about transition condition between wet and dry season at which sand dune develop actively.



Source : Barongan Climate Station

Figure 6. Monthly Average Rainfall Year 1986 - 2006

Prevailing wind in Parangtritis was derived from annual data observed in Cilacap Station about 100 km west of Parangtritis as can be seen in Table 4. Based on the annual wind data, prevailing wind was dominated by southeast wind which usually occurs during April – November and correspond to dry season.

Southeast wind which is usually strong and constant, initiates waves from the southeast and south direction. The waves will generate longshore current which moves the sediment to the west. At that time, the discharge in the Opak river has decreased and could not prevent the clogged of the river mouth by sediment due to waves activity. The closure of the river mouth by sediment causes flood in the rainy season when the discharge increases.

In the rainy season, wind blows from the west and northwest direction and initiates wave from southwest direction. Wind speed is relatively low comparing to that of southeast wind. Longshore current shift to the east direction. At that time Opak river discharge increases which keeps the river mouth open.

Table 4. Mean Wind Direction Observed in Cilacap Area

Wind Dir.	**Months**											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
N	3.69	1.96	2.09	1.85	1.25	0.89	0.56	0.21	0.33	0.66	0.84	1.76
NE	1.07	0.27	0.81	1.1	2.15	1.56	2.16	1.76	1.76	1.85	1.39	0.86
E	4.86	4.71	6.45	*11.46*	*19.79*	*24.16*	*23.86*	*25.45*	*23.12*	*19.12*	*13.18*	7.21
SE	9.92	9.25	**20.09**	**40.66**	**42.6**	**46.58**	**59.11**	**61.68**	**64.35**	**58.43**	**41.32**	**20.97**
S	6.66	5.51	8.93	3.09	2.14	2.43	1.43	3.03	2.63	2.61	8.95	11.38
SW	11.28	12.82	9.63	3.35	1.97	0.89	0.59	0.2	0.14	0.99	4.21	*12.01*
W	**19.71**	**24.24**	11.76	6.09	4.23	2.87	1.24	0.74	0.73	0.4	4.18	9.42
NW	*16.93*	*19.22*	*13.88*	9.41	5.26	3.21	1.57	0.28	0.48	1.37	3.56	9.27

Maximum measurement is printed in bold, second percentage is underlined.
Source : (Puser Bumi 1993) cited in (Sugeng *et al.* 2002)

3.1.4 Geomorphology

Parangtritis beach stretches along approximately 7 km in east-west direction, started from cliff in the east to the Opak River mouth in the west. According to Sunarto (2008) Parangtritis is classified as a depositional coast.

Source: Google Earth

Figure 7. 3D View of Parangtritis (Quickbird image drapped in DEM, processed in Global Mapper)

Hendratno (2000) divides Parangtritis into 2 landforms i.e.: Parangtritis coastal lowland and Parangtritis coastal highland. Parangtritis coastal lowland is characterized by sandy volcanic beach, while coastal highland is marked by limestone cliffed coast and andesite cliffed coast. The beach profile in the coastal lowland shows the existence of foreshore, backshore and dune while in coastal highland, coastline is directly coincide with cliff.

Parangtritis beach grain size distribution gradually change in diameter from east to west (Sutikno et al. 1988). At the east part, the beach has relatively fine sand and gentle slope while in the west part, grain size is relative coarse and steep slope. Near the mouth of Opak River and surroundings, very coarse sand to gravel is found. It can be inferred that mostly, sand deposited on Parangtritis is derived from the Opak River.

3.1.5 Oceanography of the South Coast of Central Java

Parangtritis beach is directly facing Indian Ocean and therefore subjected to Indian Ocean's high wave energy. Data derived from US Navy Marine Climatic Atlas of the World Volume 3 Indian Ocean (1976) reported by JICA (1988) cited in Triatmojo (1999), based on 120 year statistic pointed out that wave from south direction with 1-2 m in height has dominated about 20% of waves occurrence (Table 5.)

Table 6. Wave Height In Indian Ocean

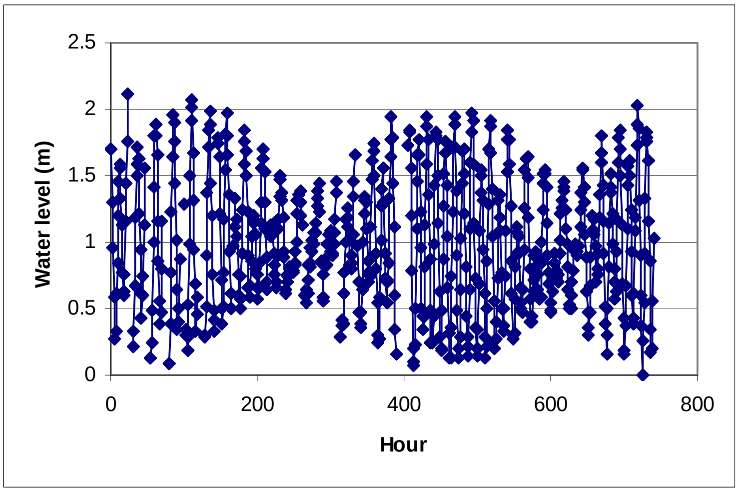
Wave height	Percentage (%) of occurence		
H (m)	Southeast	South	Southwest
0 – 1	4,67	3,02	2,54
1 – 2	9,89	20,27	7,79
2 – 3	4,48	7,54	5,07
> 3	0,56	1,89	1,13

Source : US Navy Marine Climatic Atlas of the World Volume 3 Indian Ocean

South and Southeastern waves in relation to general orientation of the shoreline has generated alongshore currents toward the west direction. Indications of this are that material deposited in the mouth of Opak River form coastal gradation to the west direction.

In more general sense, the pattern of surface current along the south coast of Java as has been recorded by Wyrtki (1961), showing that during the months December - June surface current is directed to the East while during August - October it changes to the West.

Tide pattern in Parangtritis is mixed predominantly semidiurnal type. This type of tide has high and low tides twice a day. Water level between successive high tides or low tide has distinctive height. In this tide pattern, the successive high tides separated approximately by 12 hour time period.



Source : Sadeng Tide Gauge Station

Figure 8. Tide Pattern : Mixed, Predominantly Semidiurnal

3.2. Social Economic Setting

3.2.1 Population

The amount of people living in Parangtritis village is the second highest after Donotirto village, but has the least population density among all villages in the Kretek sub-distric, due to the vastness of the area as can be seen in Table 7. below..

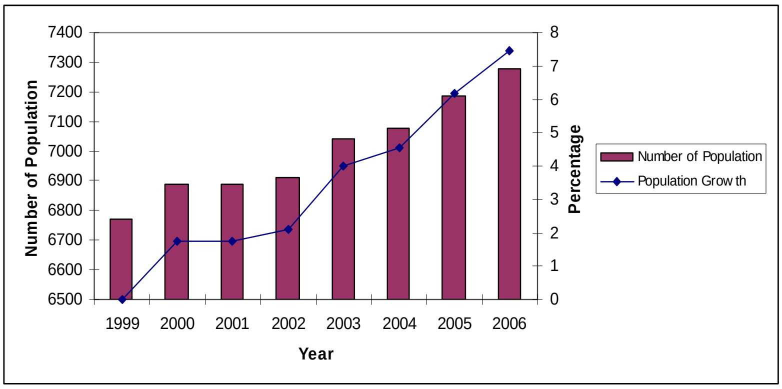
Table 7. Population Density of Kretek Sub-District

Village	Area	Number of population Year 2006	Density (live/km2)
	(KM2)	(live)	
Tirtohargo	3.62	2,921	807
Parangtritis	11.87	7,276	613
Donotirto	4.7	9,319	1,983
Tirtosari	2.39	4,757	1,990
Tirtomulyo	4.19	7,206	1,720
Kecamatan	26.77	31,479	1,176

Source : Central Statistic Board

Population growth in Parangtritis as can be seen in Figure 9. indicates a rapid growth in the year 2003. The increase number of population might be due to local migration that indicated by the increase of built up area. According to Annihayah (2008), during 1998-2003 many people trigerred by economic unstability, started informal bussines by utilize open area espescially Sultan Ground (land owned by Sultanate).

Considering the situation, it might be during that periode many people moved to Parangtritis to have an opportunity in informal bussiness. It seems that the situation continues until now since Parangtritis is becoming an tourim icon in the South Coast of Yogyakarta.



Source : BPS

Figure 9. Population Growth in Parangtritis Village during 1999 – 2006

3.2.2 Landuse

Parangtritis village constitutes of the largest village in Kretek Sub-district, has area extent of 1.1878 ha which covers almost half of the sub-district. Most of the landuse is unirrigated agricultural field followed by irrigated rice field. Mixed garden and settlement relatively equal and the rest of them are rain-fed rice field, bushes, sand and grass (Hara 2007).

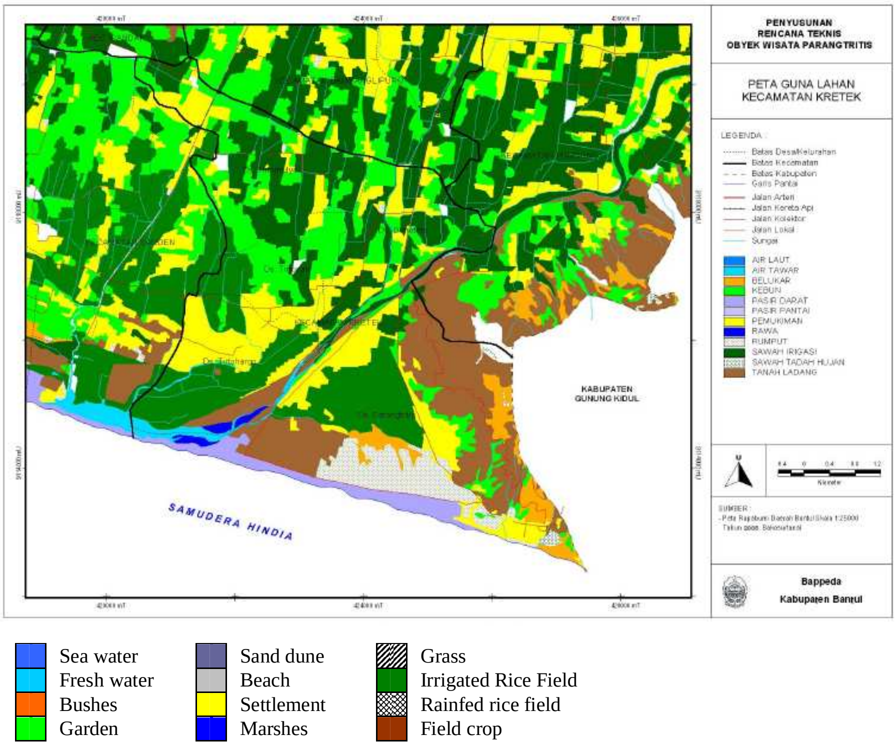


Figure 10. Landuse Map of Kretek Sub-district (Hara 2007)

4. LITERATURE REVIEW

4.1. Coastal Disaster

According to Indonesian Disaster Management Bill, disaster is defined as event or series of events that threaten or disturb community life caused by natural, non-natural or human factor and bringing losses of properties, even lives of the community.

Coastal disaster is defined as an even caused by coastal dynamic that damaging coastal environment and bringing losses of properties, even lives of the community in the coastal area. Coastal dynamic is understood as changes in coastal area caused by the interaction of seven factors that operate interactively and inter-dependently. Those are astro-dynamic, aerodynamic, hydrodynamic, morphodynamic, ecodynamic and antropodynamic (Sunarto 2008).

Further, Sunarto (2008) classified coastal disaster into (1) Natural Disaster which is consist of storm waves, tidal waves, tsunami, marine erosion, sedimentation; (2) Non-natural disaster which is consist of coastal structures failure, coastal spatial planning failure, depraved of coastal ecosystem such as coral reef, mangrove, coastal forest, pollution on sea, beach and coast; (3) Social Disaster such as social conflict and crime.

In order to alleviate consequences of being threaten by coastal disaster, effort by means of mitigation should be considered. Indonesian Disaster Management Bill defined mitigation as series of efforts to reduce disaster risk by means of structural / physical development or capacity building. Further, the bill described that the mitigation consist of spatial planning, building code and community capacity building through education, information and training.

4.2. Geographic Information System

The recent study employed the advantages of GIS and remote sensing. GIS is a computerized system that facilitates data entry, data analysis and data presentation, especially with georeferenced data. The capabilities to handle georeferenced data include data capture and preparation, data management (storage and maintenance), data manipulation and analysis and data presentation (By *et al.* 2004).

GIS technology is distinguishable from other information system because GIS technology has capabilities in integrating common database operation such as query and statistical analysis with the advantages of maps such as visualization and geographic analysis. These abilities make GIS used in a wide range of public and private sector for explaining, predicting and planning activities.

4.3. Shoreline

4.3.1 Shoreline Definition

The terms shoreline and coastline are often used interchangeably to refer the same feature in coastal area, i.e.: boundary between land and water body, as seen in Guariglia et al. (2006), White (1999) and Moran (2003).

According to Shalowitz (1964) cited in Graham et al. (2003), shoreline is defined as "the line of contact between the land and a body of water. On Coast and Geodetic Survey nautical charts and surveys the shoreline approximates the mean high water line. In Coast Survey, the term is considered synonymous with coastline".

However, there are some literatures that clearly distinguished shoreline from coastline. According to Shore Protection Manual (Coastal Engineering Research Center (CERC) 1984), shoreline is defined as the line contacting between the mean high water line and the shore. More over, Shore Protection Manual also describes that in contrast to the shoreline, coastline is more easy to identify based on a clear morphological shift between the shore and the coast.

Further, coastline is described as the line that technically forms the boundary between the coast and the shore, i.e. the foot of the cliff or the foot of the dunes. Commonly, the line that forms the boundary between the land and the water as described in Figure 11.

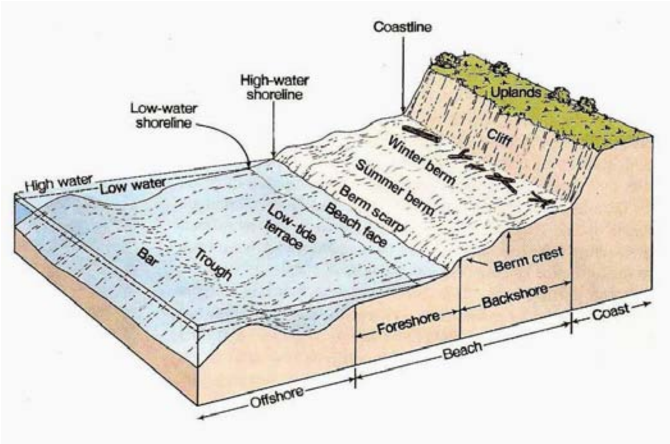


Figure 11. Coastal Term (Sverdrup *et al.* 1992)

It can be inferred that shoreline is water edge that moving according to the water level which make it not easy to recognize in the nature. Those definitions above indicated that shoreline refer to more specific feature in the coast that indicated place where body of water meets land in certain position, while coastline refer to more fix and general term.

Shoreline is an important feature for Indonesia as an archipelagic state. Shoreline feature is used in many aspects, covering from legal to development processes, from the establishing of national and regional boundaries to the arrangement of spatial planning.

According to Survey and Mapping Dictionary (PU no date), shoreline in general term is defined as a line that delimitates land and waterbody. More specific, in the same source, Dishidros TNI AL (NAVY hydro-oceanography agent) describes shoreline as a line that delineate shore at highest high water level, while Bakosurtanal uses mean sea level to depict shore curvature in their maps. It is obvious that in Indonesia, shoreline is a line where water meets the land in certain position according to water level that may differ on intended usage.

Shoreline and it's definition has been used in some Indonesian regulations, both national and regional level such as Coastal and Small Islands Management Bill, Ministerial of Home Affair Ordinance No. 1/2006 about Regional Boundaries or Yogyakarta Province Spatial Planning Ordinance. Commonly water levels used are "air pasang tertinggi" (highest high water level) and " air surut terendah" (lowest low water level).

Water levels as mentioned in regulations above, as they confirmed with scientific terms, have potential of being multi interpreted since there are so many scientific terms to describe water level e.g.: highest high water level, mean high water spring or even highest astronomical tide which are differs among other and could lead to different result in the application. The different result best described by Bird (1984) which shows the variation of tidal curves, tide range from highest astronomical tide to lowest astronomical tide that affect shoreline position.

However, Hafidz (no date) stated that the most common vertical datum used are Mean Sea Level (MSL), Chart datum /Lowest Low Water Level (LLWL) and Mean Highest High Water (MHHW) (see Figure 13.).

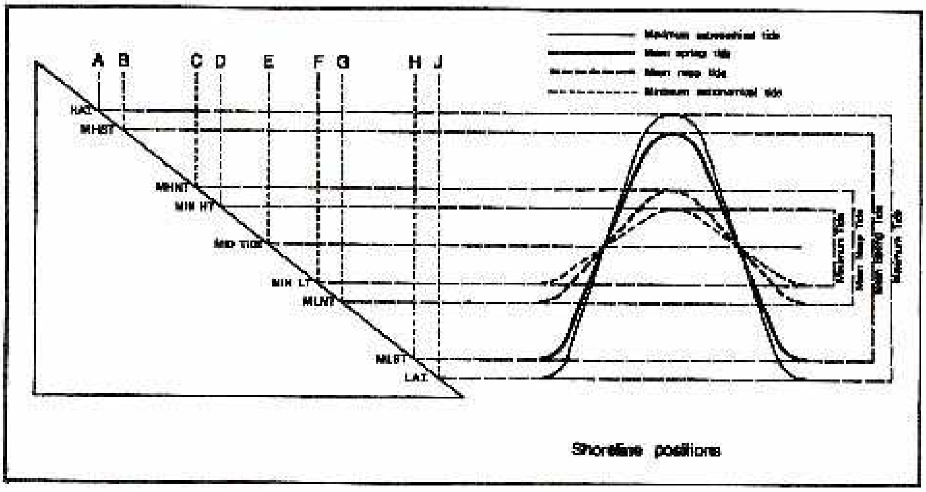


Figure 12. Variation on Tidal Curves, Tide Range and Shoreline Position from A (highest Astronomical Tide) to J (Lowest Astronomical Tide) (Bird 1984)

The definition of MSL, LLWL and MHHW are outlined below as cited on Poerbondono (2000)

MSL is defined by IHO Dictionary, S-32, 5th Edition, 3156 as :

"The average height of the surface of the sea at a tide station for all stage of the tide over a 19-year period, usually determined from hourly height readings measured from fixed predetermined reference level."

LLWL is defined as :

"An arbitrary level conforming to the lowest tide observed at a place, or some what lower".

MHHW is defined as :

"The average height of higher high water at a place over a 19-year period"

Suprapto (1993) stated that in reality it is difficult to obtain MSL, nevertheless, for certain purpose, Mean Water Level (MWL) is considered same as MSL. IHO Dictionary, S-32, 5th Edition, 3156 defines MWL as:

"the average of all hourly water level over the available period of record".

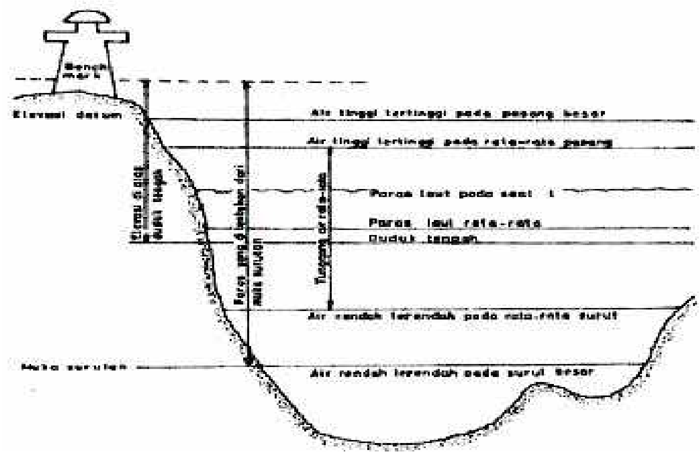


Figure 13. Datum Vertical (Hafidz no date)

In the recent study, shoreline definition follows Shallowitsz which used Mean High Water Line (MHW) as shoreline. This was done because the study attempts to asses shoreline changes by comparing shoreline position derived from different sources, such as topographic maps, aerial photographs, satellite image and field survey. Assessing shoreline changes by comparing shoreline positions only yielded valid information if shorelines compared are in the same datum.

4.3.2 Shoreline Indicator

Since that shoreline is defined as the line contacting between the mean high water line and the shore, defining the position of this line is not a trivial task. The location of the indicator is influenced by natural variability of beach morphology and water level.

Shoreline indicator could be identified by using beach morphological feature and non morphological feature. Morphological features are those physical shoreline such as berm crest, scrap edge, vegetation line, dune crest, et,. While non morphological features are those related to water line as wetted boundary, wet-dry boundary, wet sand line, etc.

Those associated with water level such as high water line (HWL), mean high water line (MHWL), mean lower water line (MLWL), derivate from the local tidal datum can be classified as mathematical shoreline (Alves 2007).

Shoreline indicator best described trough Figure 14. below.

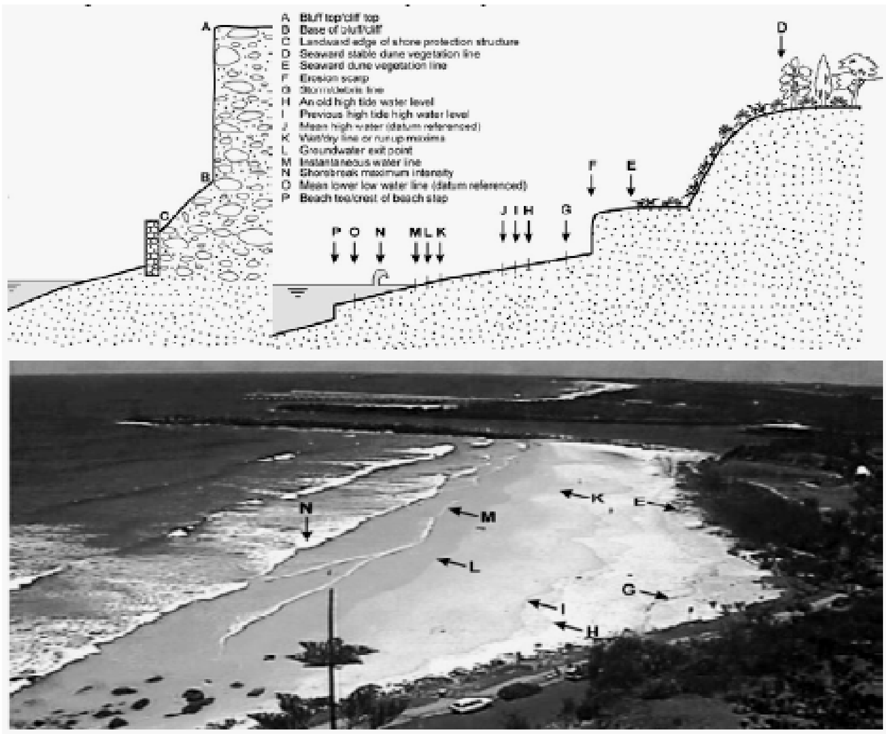


Figure 14. Commonly Used Shoreline Indicator (Alves 2007)

4.3.3 Shoreline Mapping Technique

Shoreline data was traditionally performed manually, digitizing shoreline from topographic maps, or interpreting and tracing shoreline from aerial photographs. Recent technology allowed the automation of digitizing shoreline by using digital image processing methods (Li et al. 2001) (Bagli et al. 2004) (Di et al. 2003).

Shoreline generation which based on remotely sensed data such as aerial photograph and satellite imagery, produced so called "instantaneous shoreline" which is representing shoreline correspond to water level at the time of image acquisition. This is excluding the aerial photograph that taken in the time that water level is at the approximate elevation of the desired tidal datum which called tide-controlled photogrametry (Hess 2003).

In practice, instantaneous shoreline can not be use for mapping or quantifying shoreline changes. Shoreline based on stable vertical datum can be threatened as reference or quantifying shoreline changes. This is usually called tide-coordinated shoreline (Li et al. 2002). In order to apply spatial analysis for investigate shoreline changes using GIS software, reliable result is only yielded from a similar vertical datum shorelines.

Another technique in mapping shoreline is crossing a given water level to coast-bathymetry contour. This technique is derived from the definition of shoreline that indicated "the line of contact between the land and a body of water". A land model and water surface model (WSM) is created and then compute the intersection line of these two models. This method is intuitive to people's perception of shoreline. The CTM depicts the elevation and bathymetry in the coastal area (Li et al. 2001).

In the absence of bathymetry contour, shoreline can be produced by assigning certain elevation into Digital Elevation Model (DEM) of coastal area. To generate DEM, elevation points are requested. They can be provided by terrestrial survey or airborne LIDAR survey.

Technique to generate shoreline from DEM has been provided by Harris (2005). They combined LIDAR-based DEM with GPS tracking survey to extract shoreline. GPS tracking line was converted into point vector and overlain into LIDAR-based DEM and the elevation value under each point was extracted. The elevation values were averaged to obtain a contour elevation that could be generated from the DEM. Shoreline obtained was represent water level when GPS tracking was done.

4.3.4 Accuracy Associate With Shoreline Mapping

Comparing shoreline derived from successive maps and aerial photos is challenging considering shoreline maps should be brought into common datum, scale, projection and coordinate system before they can be compared

(Anders et al. 1991). Although computerized system has assisted the use of maps for comparing shoreline position, inherent error in each map source still need to be eliminated or minimized. At this section of literature review, the author heavily cited that from Anders and Byrnes (1991) since they provided comprehensive information dealing with error estimation on shoreline changes derived from maps and aerial photographs.

Shoreline measurement from historical maps can only reliable as the original maps themselves. Referring to United States National Map Accuracy Standard, maps with scale larger than 1:20.000 only tolerate to have 10% of points tested in error by more than 0.846 m, while for scales 1:20.000 or smaller, 0.508 mm. Considering statement above, a map with scale 1: 50.000 only allowable to have maximum error 25 m in the ground.

Aerial photograph has variety of intrinsic distortions, therefore it cannot directly treated as map. These include : 1) radial distortion, 2) tilt and pitch and 3) scale variations caused by changes in altitude along flight line. Following Janssen (2004), by georeferencing aerial photograph (of flat terrain) using perspective transformation or more generic one, the polynomial transformation, the effect of pitch and roll can be corrected.

4.3.5 Shoreline Change Detection and Rate

The study of historical shoreline data can be useful to identify the predominant coastal processes operating in specific coastal locations using change rates as an indicator of shoreline dynamics. The real importance of such studies is to avoid decisions based on insufficient knowledge, wrong assessments or arbitrary decisions, leading to losses in resources and infrastructure that could have been prevented (Moran 2003).

Temporal comparison to detect changing in shoreline position can be done manually by establishing transect perpendicular to the composite shoreline maps at desired spacing along the coast (Anders et al. 1991). The measured distance is divide by time interval between shoreline to determine the change rate. For quantification shoreline changes that covers large area, automated technique can save amount of time. The procedure is similar to the manual technique.

Several statistical methods are used to calculate the shoreline change rates with the most commonly used being end-point rate (EPR) calculations or linear regression (LRR) (Dolan et al. 1991). End-point rate calculations are simply the rates determined based on the changes in position between the oldest and most recent shorelines in a given dataset. Linear-regression rates are the result of estimating the average rate of changes using a number of shoreline positions over time. The shoreline change rates can then be used to extrapolate future changes in the shoreline (Crowell *et al.* 1997) in Ferreira (2006).

Description of methods to calculate shoreline change rate taken from Tutorial of Digital Shoreline Analysis System (Thieler et al. 2003) as follow:

End Point Rate (EPR) Method

The end point rate is calculated by dividing the distance of shoreline movement by the time elapsed between the earliest and latest measurements (i.e., the oldest and the most recent shoreline). The major advantage of the EPR is its ease of computation and minimal requirement for shoreline data (two shorelines). The major disadvantage is that in cases (like Massachusetts) where more than two shorelines are available, the information about shoreline behavior provided by additional shorelines is neglected. Thus, changes in sign or magnitude of the shoreline movement trend, or cyclicity of behavior may be missed.

Average Of Rate (AOR) Method

The average of rates method was developed by Foster and Savage (1989). This method involves calculating separate end-point rates for all combinations of shorelines when more than two are available, and can be extended to incorporate the accuracy of the shoreline position data and the magnitude of the rate-of-change by using a minimum time criterion, T min :

$$T_{\min} = \frac{\sqrt{(E_1)^2 + (E_2)^2}}{R_1}$$ Equation 1.

where E 1 and E 2 are the measurement errors in the first and second shoreline point, and R 1 is the EPR of the longest time span for the transect (Dolan and others, 1991).

T min is the minimum amount of time that must elapse between measured shorelines to ensure that the AOR calculation produces results that exceed measurement error. The AOR method also produces a measure of the standard deviation and variance of the data. If only two points are available, and the T min requirement is met, then the AOR is the same as the EPR.

Average Of Era (AOA) Method

An "average of eras" rate-of-change is calculated simply by adding each rate-of-change for individual time periods (eras) and dividing by the total number of eras. This results in an overall average for all time periods combined. Its advantage is that it allows for calculation of measures of variation within the data, e.g., variance and standard deviation, and was included in the modified Digital Shoreline Analysis System (DSAS) programming provided by CZM. Despite its advantage, the average of era rate methodology is generally not a common statistic used in generating shoreline change rates.

Linear Regression Rate (LRR) Method

A linear regression rate-of-change statistic can be determined by fitting a least squares regression line to all shoreline points for a particular transect. The rate is the slope of the line. The advantages of linear regression include: 1) all the data are used, regardless of changes in trend or accuracy; 2) the method is purely computational (requires no other analysis such as measurement errors used in the AOR method); 3) it is based on accepted statistical concepts; and 4) it is easy to employ. As pointed out by Dolan and others (1991), the linear regression method is susceptible to outlier effects, and also tends to underestimate the rate-of-change relative to other statistics, such as EPR.

Jack Knife (JKF) Method

The jackknife method is implemented as an iterative linear regression that calculates a linear regression fit to shoreline data points with all possible combinations of shoreline points, leaving out one point in each iteration. The slopes of the linear regression lines are averaged to yield the jackknife rate. The advantages of the jackknife are similar to linear regression; the jackknife is also less influenced by outliers of data clusters. The main disadvantage of the jackknife is a lack of increased statistical value given the typically small numbers of shoreline data points used to derive a shoreline rate-of-change. Most historical shoreline studies have < 10 shorelines, and the real statistical power of the jackknife is best utilized with an order of magnitude (or more) data points.

4.4. Digital Elevation Modeling (DEM)

Digital Elevation Model (DEM) is defined as digital representation of land surface topography or elevation. DEM used widely in GIS project and serves as a basis for a large derivative information Commonly used method to crate DEM is by interpolating ground point, either derived by survey or trough photogrammetrical technique. If ground point derived either by ground survey or photogrammetrical technique is unavailable, interpolation of contour line digitized from existing map can generate a DEM (Nijmeijer *et al.* 2001)

4.4.1 DEM Interpolation Methods

DEM may be developed based on different interpolation method. Interpolation process converts height value which originally stored in points into coverage, which contain elevation value for the whole area. Most commonly used interpolation method are Triangulated Irregular Network (TIN), Moving Average and Kriging.

Triangulated Irregular Network (TIN)

The TIN model represents a surface and is constructed by triangulating a set of points. The points are connected by lines to form a network of triangles.

Within each triangle the surface is usually represented by a plane. By using triangles, each piece of the surface will fit with its neighboring pieces so the surface will be continuous (Poiker 1990; Tchoukanski 2008).

Points can be picked at any location, but well placed points will produce a more accurate model of the surface. A well placed point can be obtained by placing point in the area where there is major change in the area such as peak of a mountain and valley's floor.

The TIN model is simplicity and economy because it can represent surface from irregularly sampled points, with more points in areas of rough terrain and fewer in more smooth terrain.

Moving Average

The Moving average operation is a point interpolation method in which the output of interpolated elevation are the weighted averages of input point values. Weighted averaging is the calculation of the sum of the products of weights and point values, divided by the sum of weights (Nijmeijer *et al.* 2001). The weight factors are calculated by a user-specified weight function.

There are two methods in conducting weigh function: inverse distance and linear decrease. Both methods make certain that points which are close to an output pixel obtain large weights and that points which are farther away from an output pixel obtain small weights. This means that values of points closer to an output pixel more influence the output pixel value than the values of points that are farther away.

Kriging

Kriging is generic term for a family of least-squares linear regression algorithm that are used to estimate the value of a continuous attribute at any unsampled location using only attribute data available over the study area. (Jensen, 2005). Kriging assumes that values at short distance are more likely to be similar than that of larger distance. The elevation value at each pair then compared and expressed as variance and covariance. The spatial structure then analyzed trough semi variance method.

To decide which method give the best representation of the topography of the study area, the DEM quality assessment should be conducted for each interpolation method.

4.4.2 DEM Quality Assessment

DEM obtained should be assessed in term on how accurate it represent real condition. There are two approach to assess the quality of the DEM i.e. statistical method and visual method (Susetyo 2008). Statistical method define the quality by calculate the difference value between interpolated and observed point. Commonly used statistical method is Root Mean Square Error (RMSE). Formula to calculating RMSE is :

$$\text{RMSE} = \sqrt{\frac{\sum (Z_i - Z_j)^2}{n}} \qquad \text{Equation 2.}$$

Where Z_i is the interpolate elevation value, Z_j is a observed value and n is number of samples.

The visual method is by using visual assessment by means comparing DEM with actual topology of the area. This method requested knowledge about geomorphology of the area.

4.5. Visual Interpretation

Visual image interpretation is the most sensitive way to derive information from remote sensing images. This process is based on person ability to relate color and pattern in an image to real surface feature (Janssen 2004).

There are seven interpretation element used to guide the interpreter conducting visual interpretation. Those are :

Tone/hue : Relative brightness of black/white image. Tone refer to color on the image. Tonal expression is generated from amount of energy reflected from the object surface. The variation are related to spectral characteristic of the object and also band selection for visualization.

Shape or form explain terrain object visible in the image. In stereo image it can relate height difference which are important to distinguish between different vegetation type and also geomorphological mapping. The shape of object often help on determining the character of objects .

Size of object is relative or absolute of sense. For example, the width of road can be estimated by comparing with a car size. This way subsequently can determine road type.

Pattern is spatial arrangement of object implies the characteristic repetition or certain form of relationship. Pattern can be describe by term of concentric, radial, checkerboard etc .

Texture may describe by term of coarse or fine, smooth or rough, even or uneven, mottled, speckled, granular, linear, wooly etc. It relate to the frequency of tonal changes and to spatial resolution of the sensor applied.

Site illustrated topographical or geographic location. For example, backswamp can be found in floodplain but not in the city center.

Associate illustrates the fact that the combination of object make it possible to conclude about it meaning or function. Example. Landuse pattern associated with small scale farming will be characteristically different to that of large scale farming .

4.6. Landuse

Landuse has been noted as an important factor in planning and environment modeling activities (Danoedoro 2004). Conceptually, landuse is different from land cover. Clawson and Steward in Rhind, D. and R. Hudson (1980) define landuse as man activities on land which are directly related to the land, while land cover is termed : "the vegetation and artificial construction covering the land surface". Another scientist, Campbell, highlighted that the different of landuse from land cover is in the context of concrete and abstract; land cover is concrete while landuse is abstract.

In further detail, Veldkamp and Fresco stated that landuse refers to human activities that are directly related to land, making use of its resources and interfering in the ecological processes that determine the functioning of land-cover. It is influenced by the potential value of the land for agricultural, forest, urban, or nature protection use and is governed by multilevel economic and socio-cultural interactions. Otherwise, land-cover refers to the surface appearance of the landscape, which is mainly affected by its use, its cultivation and the seasonal penology.

4.6.1 Landuse Data Sources

To study landuse change, it is necessary to create landuse maps in two or more than two dates. According to Rhind (1980), the data for creating landuse map can be derived from several forms i.e.:

Lists and texts : This kind of data source usually time consuming on extracting its information and often necessitates expert knowledge of the source and possibly geographical area concerned despite its advantages on providing the earliest landuse data.

Maps : Data taken from maps is derived from field survey and translated into map. One of the longest geographically detailed historical time series is available from topographic maps.

The advantages of map as data source are that they are inexpensive, provide good resolution and good position fixing also conveniently sampled. The disadvantages are lack of synchronicity (different map sheets are revised at different time), crude and occasionally inconsistence classification of landuse. Beside, the information in topographic map is more land cover rather than landuse.

Remote sensing : this definition embrace the detection, measurement of object by some device physically separated from them often by considerable distance. The advantages of this method over the preceding one are the consistency of data collection, rapidity of survey and small number of skilled worker at data collection stage. However, information derived from remote sensing has to be incorporate with other information to obtain landuse information.

4.6.2 Landuse Classification

There is no ideal classification of land cover/landuse which satisfy the need of all surveyor, therefore, although has been defined conceptually different, classification scheme in many research activities often use landuse classification be conformity, or interchangeable with land cover classification.

In Indonesia, many classification scheme has been developed such as that by Malingreau and Cristiany (1982) also those used by Bakosurtanal and BPN. However, those classification scheme often used landuse and land cover term interchangeably as a result of the usage of remote sensing as data source (Danoedoro 2004).

Danoedoro (2004) proposed versatile landuse classification system that pervade landuse and land cover aspect in distinctive manner. Distinction was carried out by categorize both in vertical (detail) and horizontal (spectral, spatial, temporal, ecological, functional and legal dimensions).

Nevertheles, in recent study, landuse classification was adopted Malingreau's classification (1982). Since that analyzing involved different data type such as topographic map and aerial photographs, two level landuse classification was used. Classification scheme and code is given in table below, followed by the definition for each class.

Table 8. Landuse Classification

Code	Level 1	Code	Level 2
K	Built up	*Kp*	*Settlement*
		Kk	*Cemetery*
S	Rice field	*Si*	*Irrigated rice field*
		Sr	*Rain fed rice field*
U	Upland crop	*Ut*	*Field crop*
		Uk	*Mixed garden*
D	Barren land	*Dg*	*Beaches*
		Dp	*Sand dune*
		Ds	*Sand bar*
W	Water bodies	*Wd*	*Lake*
		Ws	*Stream*
B	Bush/shrub	*Bb*	*Continuous thicket*
		Bs	*Scattered shrub*

The definition for each class are as follow :

Built-up Areas, Settlement : area used for living and conduct livelihood activities.

Rice field : cultivated area with level fields surround by bunds and supporting at least one crop of rice in the rotation. This class further divided by two :

Irrigated rice field, rice field that are artificially supplied with water.

Rainfed rice field , rice field that are only watered by impounded rain water, some time supplemented by very localized run off collection system.

Upland crop : area occupied by rainfed crop on the original topography or on benched slope. Further division are :

Field crop: grain, root or fiber crops growing in open field (benched or not). Fallows are rare and only for short terms. Seasonality is controlled by the rainfall pattern (and/or labor availability). Trees and bushes, if any, are confined to the edge of the field.

Mixed garden : field occupied by field crops, mixed with trees and bush crops (often fruits).

Barren land : area devoided by vegetation because of erosion; soil or bed rock are apparent. Further division are :

Beaches : sloping accumulation of sand and gravel usually devoided of vegetation.

Sand dunes : accumulation of sand of aeolian origin, covered with grass or low bush, planted with coconut or devoided of vegetation.

Lake : an extensive sheet of water enclosed by land, occupying hollow in the earth surface.

Bush/shrub : formation of low woody plant, often interspersed with trees and grass.

4.6.3 Landuse Changes Assessment

Change detection is the process of recognizing the different state of an object or phenomenon by observing it at different times (Singh 1989). Change detection is essential in monitoring and managing natural resources and urban development because quantitative analysis of the spatial distribution of the population of interest can be done.

Changes of landuse are caused by modified biophysical or human demands that arise from changed natural, economic or political conditions. The consequences are either modification or conversion: modification implies a change of condition within a type, caused by different cultivation techniques or management strategies; Conversions include a transition from one land-use type to another.

4.7. Coastal Spatial Planning

Planning is a process for setting goals to be achieved in the future and determining steps required to achieve the goals. Therefore planning is involving of probing the possible course and explore the uncertainty that prevent the ability to choose the direction of action confidently (Kay et al. 1999).

Spatial planning, according to European Commission (1997)**,** is the methods used largely by the public sector to influence the future distribution of activities in space. The aims is to create a more rational territorial organization of landuses and the linkages between them in order to balance demands for development with the need to protect the environment to achieve social and economic objectives.

Dulbahri (2005) stated that coastal spatial planning can not fully follow that of land spatial planning because the characteristic of coastal area differs than that of the land. Planning process in coastal area are very much influenced by stricth division of preservation zone due to it's dynamic but vurnerable characteristics.

It can be infferred that coastal spatial planning embraces the definition of spatial planning with pay great attention to the unique characteristic of coastal area.

4.7.1 National and Regional Policies

Spatial planning in Indonesia is regulated trough Spatial Planning Bill, in which it defined as a process to plan, utilize and control the utilization of space. The aims of spatial planning is to achieve a safe, pleasant, productive and sustainable condition.

Particularly for coastal area, management of coastal area has been regulated by Coastal and Small Island Management Bills which in it's article no 28 states that coastal area serves as conservation zone with the aims mainly to protect coastal and small island ecosystem, fish and other biotic migration path and traditional culture.

One of the special feature regarding coastal spatial planning is the establisment of coastal buffer zone, which is stated in both national level regulation above, has to be set arbitrary depend on coastal condition, minimum in the range of 100 meters from highest high water line. Further, Coastal and Small Island Management Bills, in particullar, allows local goverment to establish their coastal buffer zone with taking into account :

Earthquake and tsunami;

Erosion and abrasion;

Storm, flood and other natural disasters;

Protection of natural ecosystem such as wet land, mangrove, sea grass, dunes, estuary and deltas;

Regulation on public access;

Regulation on water ways and sewage.

Therefore, buffer zone width will vary depend on the local condition but in minimum width of 100 m from highest high water level.

4.7.2 Local Regulation

Spatial planning in Bantul Regency has been regulated by Regent’s Decree No. 4/2002 about Spatial Planning. Regarding to the development activities in coastal area, the Government of Bantul Regency has established semi detailed plan and detailed plan known as “Rencana Detail Tata Ruang Kawasan Pantai Selatan Kabupaten Bantul” or RDTRK Pantai Selatan and “Rencana Teknis Tata Ruang Obyek Wisata Kawasan Parangtritis” or RTOW Kawasan Parangtritis respectively. Concerning with land utilization in coastal area, the buffer zone of 100-200 meter from highest high water line has been established.

Detailed spatial planning concerning Parangtritis is the Regent’s Decree about Technical Plan of Parangtritis Tourism Resort Development. Based on this decree, Parangtritis has been divided into 8 zones (see Figure 15.) in which each of it has been assigned for special allotment. Those are:

Zone 1 : Beach Preservation

Zone 2 : Public Recreation

Zone 3 : Dune Preservation

Zone 4 : Cultural Preservation

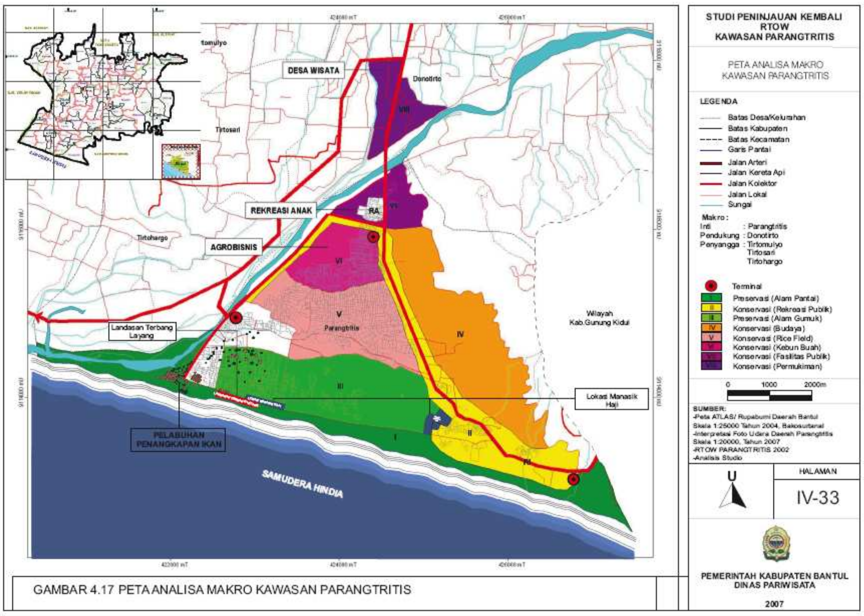
Zone 5 : Rice Field Preservation

Zone 6 : Orchard (Fruit) Preservation

Zone 7 : Public Facility

Zone 8 : Settlement

Further, based on tsunami and high wave events , the Government of Bantul established another buffer zone approximately 300 m from highest high water (Zainudin 2007; Annihayah 2008).



Zone 1 : Beach Preservation
Zone 2 : Public Recreation
Zone 3 : Dune Preservation
Zone 4 : Cultural Preservation
Zone 5 : Rice Field Preservation
Zone 6 : Orchard (Fruit) Preservation
Zone 7 : Public Facility
Zone 8 : Settlement

Figure 15. Parangtritis Meso Scale Landuse Plan

4.7.3 Coastal Spatial Planning and Risk Management

In term of risk management, there are many ways to adress risk and hazard issues as describe in Coastal Planning and Management (Kay et al. 1999). They are consist of 1) Event protection (hard or soft engineering), 2) Damage prevention (avoidance, mitigation), 3) Loss Distribution (transfer) and 3) Risk Acceptance (do nothing).

The role of spatial planning for disaster management consist of :

- Keeping areas free of development :

  Spatial planning has the instruments at hand to keep free those areas of future development that are (1) prone to hazards (e.g. flood-prone areas, avalanche-prone areas), (2) that will be needed to lower the effects of a hazardous event (e.g. retention areas) and (3) that will be needed to guarantee the effectiveness of response activities (e.g. escape lanes, gathering points etc.).

- Differentiated decisions on land-use:

  besides of keeping certain areas free of development, spatial planning may also decide on land-use type according to the intensity and frequency of the existing hazard (e.g. agricultural use of a moderately hazardous flood area might be allowed whereas residential use may be forbidden).

- Recommendations in legally binding land-use or zoning plans:

  Although recommendations about certain construction requirements belong to the area of building permissions, some recommendations can already be made on the level of land-use or zoning plans (e.g. minimum elevation height of buildings above floor, prohibition of basements, prohibition of oil heating, type of roof).

- Influence on hazard intensity and frequency (=hazard potential) by spatial planning:

  Spatial planning can also contribute to a reduction of the hazard potential, e.g. protection or extent of river flood retention areas, protective forest etc.

5. DATA COLLECTION, PROCESSING AND ANALYSIS

This chapter focused on data collection, processing and analysis conducted in this research. Data collection highlighted the field work process while processing and analyzing refer to office work.

5.1. Data Collection

Data collection in term of field work was mainly to obtain 1) ground control points for georeference process, 2) points elevation for DEM generation and 3) Mean Water Level (MWL) shoreline digitations to generate DEM-based shoreline.

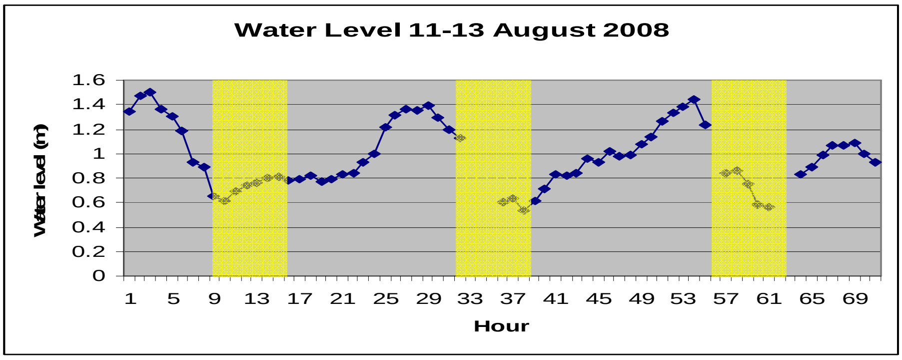
5.1.1 Ground Control Points Collection

Ground Control Point’s (GCP’s) were needed to conducting georeference process. GCP’s were collected using DGPS to get position as accurate as possible. Prior to fieldwork, aerial photographs year 1976 and Quickbird image of the study area were studied to recognize features used as ground control point (GCP’s). Aerial photographs of 1976 were studied because they provided old features possibly recognized in the Quickbird image. Beside, they also cover area exceeding that of aerial photographs 1992 and Quickbird image. Aerial photographs and Quickbird image also initially georeferenced using Yogyakarta vector map using image to map method so they could guide the Author to the intended location of GCP’s. GCP’s features comprises of road junctions, bridges, cemeteries, lava outcrop and cultural/heritages buildings.

GCP’s were measured using Differential Global Positioning System (DGPS) Trimble GeoXT and differentially corrected through post processing method. Accuracy achieved was 50-100 cm.

5.1.2 Elevation Points Measurement

Elevation points measurement for DEM generation was conducted during full moon period in which the low water level reach it's lowest level (see Figure 16). During field work, some 623 points were measured along the beach and cover from the crest of fore dune to the waterline as seaward as possible (see Figure 17). Elevation points along with GCP's were collected using DGPS Trimble GeoXT, post processing differentially corrected and achieved 50–100 cm accuracy.



Yellow stripe indicate "time window" at which field survey was conducted

Figure 16. Water Level During Fieldwork

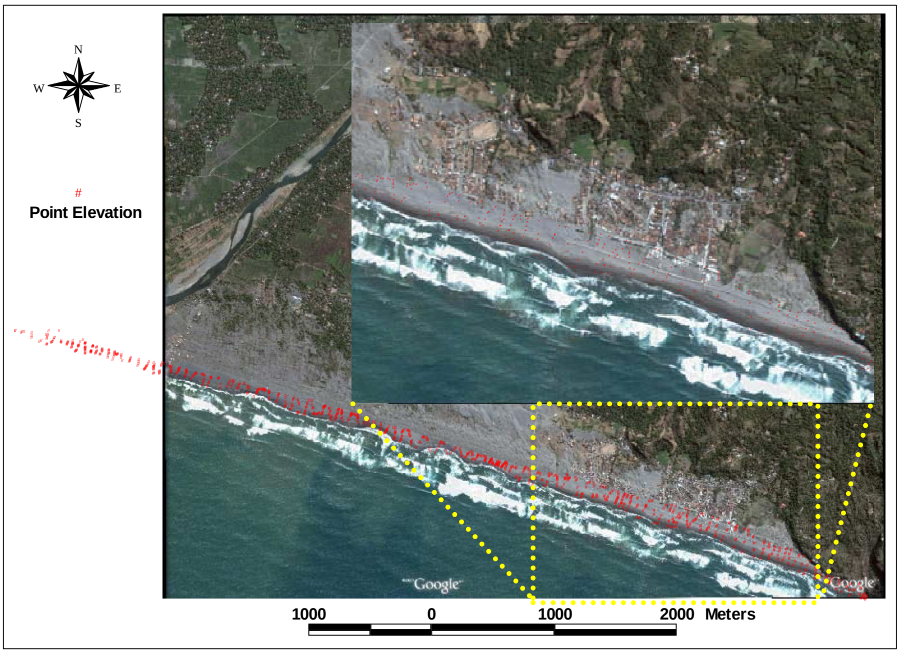


Figure 17. Elevation Points Measurement

5.1.3 Mean Water Level Shoreline Digitation

Mean Water Level (MWL) was determined based on water elevation observed in Sadeng Tide Gauge Station, some 55 km east of Parangtritis. The station was operated by Bakosurtanal and serves as a part of Tsunamy Early Warning System (TEWS) installed along the South Coast of Java. The station is equipped with real time monitoring system using 3 different sensor to monitor water level.

Based on the observed tidal data dated on 1 – 31 August 2008, tidal datum can be found in Table 9. Based on Table 9. local vertical datum for Parangtritis is the MWL value of 0.990 m.

Table 9. Tidal Datum

No	Tidal Datum	Elevation (m)
1	MHHW	1.741125
2	MHW	1.639111
3	MWL	0.990764
4	MLW	0.428381
5	MLLW	0.322387
6	Tidal Range	1.21073
7	Mean Tide	1.033746

GPS tracking along the beach was conducted in time when water level approximately reach MWL or 0.990 m according to water elevation observed in Sadeng Tide Gauge Station. The most exact way to achieve this is by conducted real time communication about the water level. Another way is by consulting with tide table. The recent study embraced both method since, during fieldwork, communication with Sadeng Tide gauge Station failed due to bad connection.

The GPS tracking was conducted along the beach and used groundwater exit point (Figure 14.) as an indicator for water level. It was impossible to have line exactly represents land-water edge in certain level since the water is not in steady state but in the dynamic movement due to wave.

5.2. Data Processing

Refer to the flowchart of shoreline changes assessment (Figure 3.) steps taken were as follow :

5.2.1 Processing Quickbird Image of Study Area

Quickbird image of the study area was downloaded from Google Earth in the form of 4 images which has overlaps among other. Prior to georeference process, Quickbird images were mosaicking using image processing software. Merged Quickbird image then georeferenced using ground GCP’s. Georeferencing process achieved RMSE 0.4165 pixel. Pixel size after georeference process was 0.72 m. That means estimated positional error was 0.299 m. Furthermore, georeferenced Quickbird image served as reference image.

5.2.2 Processing Topographic Maps

1870 Topographic Maps

The 1870 topographic maps consist of four set covering Yogyakarta province and were already available in digital (scanned) format. To facilitate georeferencing process, it was necessary to merge all four sets. The mosaicking process was carried out using Photoshop CS8. Georeference was conducted using ArcGIS in stepwise manner using image to map method by taking advantage of Yogyakarta vector map and then followed by image to image with Quickbird image as reference map.

Figure 18. Four Sheets Of 1870 Topographic Maps Before Mosaicking Process

Figure 19. 1870 Topographic Map After Mosaicking Process

In the process of georeferencing the topographic maps, it was unable to get a low RMSE. This high error might be due to the fact that the maps were old paper maps which might have shrunk. Therefore it was decided to use only a part of the study area (3rd sheet) with assumption it would reduce the error. The result of the georeference process using single sheet achieved 45.73 RMSE. Further error assessment was conducted by comparing the position of some features such as roads and road conjunctions in the topographic map relative to same features in the reference image. Shifting position between them vary from 34 – 65 m. Therefore error estimation for 1870 topographic map was taken as 65 m.

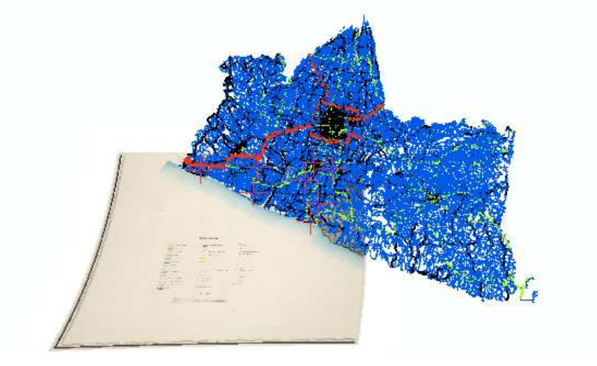


Figure 20. Georeference Proces Of A Single Sheet Of 1870 Topographic Map.

1920 Topographic Maps

The 1920 topographic maps were available in digital (scanned) format. The study area was depicted in three different sheets therefore, it was necessary to mosaick them to one sheet. (see Figure 21.). Each topographic map was georeferenced using it's original projection coordinate system (Lambert Conical Orthomorphic with Bessel spheroid). Georeference process achieved RMSE ranging from 0.3627- 0.4040 pixel. The process was carried out using ENVI software due to the familiarity of the author in the conversion processes within ENVI environment. Further, they were transform into UTM zone 49S using convert map projection facility.

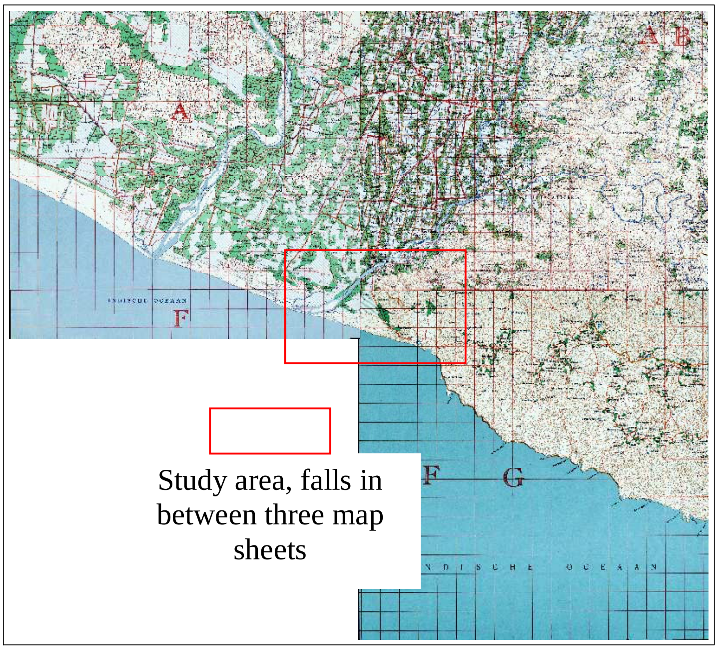


Figure 21. The mosaick of three sheets of 1920 topographic maps

5.2.3 Processing Aerial Photographs

1976 and 1992 Aerial Photographs

Aerial photographs were georeferenced using ground control points collected in the study area.

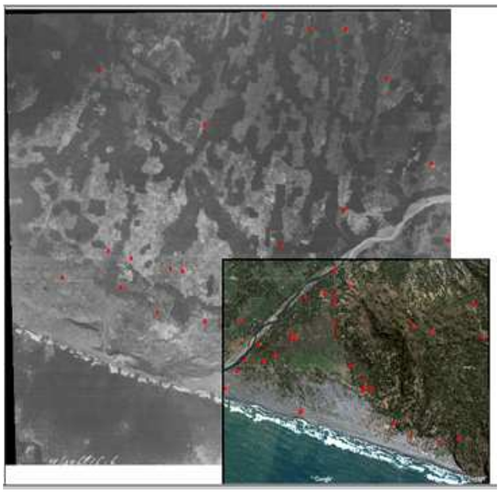


Figure 22. Ground Control Points Used For Georeferencing Aerial Photographs

Georeferencing process of aerial photograph achieved RMSE of 1.0793 0.9766 for 1976 aerial photograph and 0.4165 and 0.4959 for 1992 aerial photos.

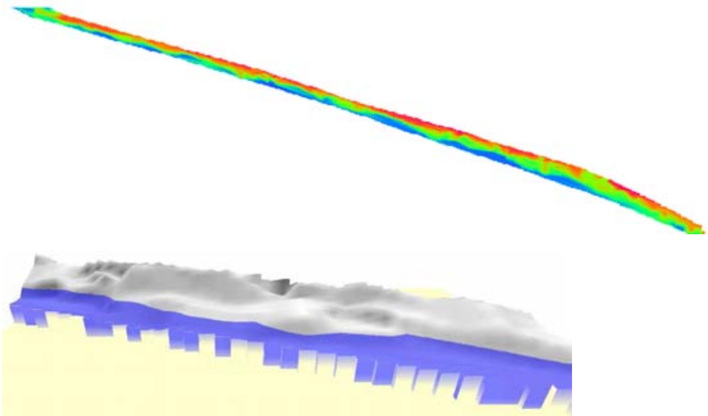
5.2.4 Processing Elevation Points

Elevation points obtained from field measurement were interpolated to generate DEM. Three different interpolation methods were employed to have DEM that represents beach topography as natural as possible. TIN, Moving Average and Kriging were chosen to be the interpolation methods. TIN was conducted using Global Mapper Software, while Moving Average and Kriging were executed in ILWIS.

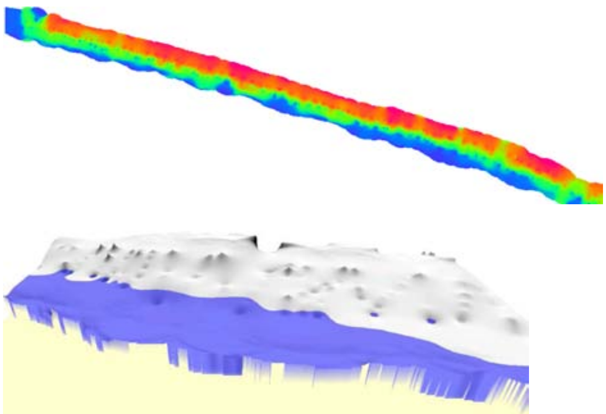
To assess the quality of the DEM, RMSE was used as indicator. RMSE value was assessed by taking advantages of crossmap function in ILWIS. In this process, raster DEM map was used as 1st input and rasterized elevation points map as 2nd input. Elevation points used were 19 elevation points that collected specially for validation purpose. Those points were collected from 3 different locations along the beach representing flat topography in the eastern part of the beach to the steep beach in the western part. RMSE value depicted in Table 10.

Table 10. RMSE of Different Interpolation Method

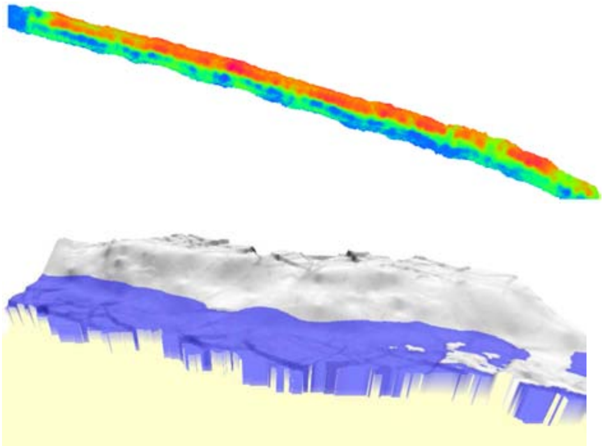
No	Method	RMSE
1	TIN	0.8715
2	Moving Average	1.4285
3	Kriging	1.0058



TIN



Moving Average



Kriging

Figure 23 Result of Different Interpolation Method and Their 3D View

Based on RMSE, TIN is performing the lowest value, followed by Kriging and Moving Average. Further inspection using 3D visualization in Global Mapper environment showing that 3D from TIN and Kriging are more realistic comparing to that of Moving Average, which tend to make sink and point when vertical exaggeration was increased. Considering the lowest RMSE also visual appearance, DEM derived from TIN interpolation method was chosen.

5.2.5 Accuracy Assessment

RMSE is one indicator for geometric correction quality. Another indicator is shifting position of some location in georeferenced data with respect to the reference data.

Table 11. Error Estimation for Each Data Set

No	Data type	RMSE	Error estimation (m)
1	1870 Topographic map	45.73	65
2	1920 Topographic map	0.3627 0.3680 0.4040	43
3	1976 Aerial photos	1.0793 0.9766	8.5
4	1992 Aerial photos	0.4165 0.4959	3.6
5	Quickbird image (reference data)	0.4165	0.2

5.3. Shoreline Generation

5.3.1 Shoreline Derived From Topographic Maps

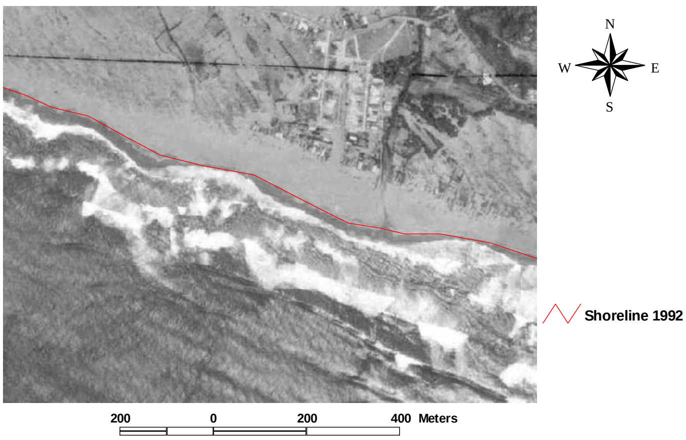
Shoreline feature from the topographic maps from the years 1870 and 1920 were obtained by on screen directly digitizing the blue line bordering land and sea. Shoreline obtained from topographic map represent the MHW shoreline. According to Shalowitz (1964) in Anders (1991), during topographic field survey, shoreline was determined from the physical appearance of the beach such as marking left by last preceding high water or barring the drift cast up by storm tides. Shoreline was then assigned as mean high water shoreline.

Figure 24. Shoreline Digitized from Topographic Maps

5.3.2 Shoreline Derived From Aerial Photographs And Quickbird Image

Shoreline feature from aerial photographs year 1976 and 1992, and Quickbird image year 2003 were digitized along the dry-wet sand boundary which could be recognized from the different tonal in sand beach. Dry sand is recognized by bright tone while wet sand is recognized by dark tone. The different tonal was caused by the different moisture in the sands as a consequences of being previously immersed or washed by previous high water level (see Figure 14.).

About aerial photographs from 1976, 1992 and Quickbird image, only information for the year 2003 was available from the Cilacap Tide Gauge Station (approximately 99 km west of Parangtritis). According to tide information, water level during the time of acquisition of the Quickbird image was 0.92 m or in falling tide. Previous high tide occurred about 5 hour before, and it's mark still recognized in the image. Digitizing shoreline in the Quickbird Image was followed the most landward mark left by previous high water (see Figure 25).



a. 1992

b. 2003

Figure 25. Shoreline Digitation Based on Dry-Wet Sand

5.3.3 Shoreline Derived From DEM

DEM based shoreline was obtained by intersecting DEM with MHW level. To get MHW level, shoreline obtained from GPS tracking was overlain onto DEM to determining average elevation which found to be 0.417 m, consequently, contour line based on 0.417 m DEM elevation created to present MWL shoreline for Parangtritis. To have MHW shoreline, another contour was generated based on summation of MSL shoreline elevation with 0.64 m (obtained from the difference of MWL and MHW on tidal datum (see Table 9). Shoreline represent MHW is used as 2008 shoreline for calculating shoreline changes.

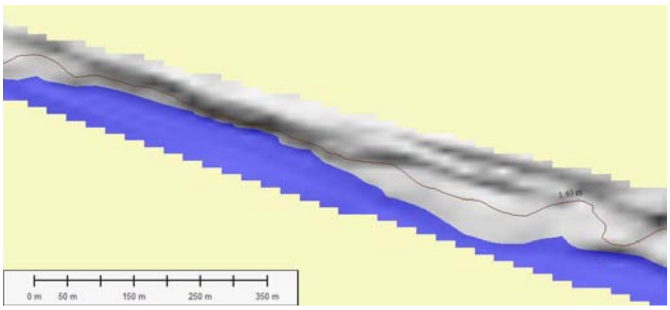


Figure 26. MHW Shoreline based on 1.06 m contour line

5.4. Shoreline Change Assessment

5.4.1 Shoreline Changes And Change Rate Assessment

Shoreline changes and change rate can be measured by quantifying the amount of shoreline shift along the transect. This procedure involved the establishment of a baseline in the direction of general orientation of shoreline, establishment of transects perpendicular to baseline in the desired spacing, and measurement of distances between shorelines along transects.

To carry out this step, Digital Shoreline Analysis System (DSAS), an extension for ArcView software developed by USGS was employed.

Baseline was generated landward and parallel to general orientation of the shoreline. Cast transects were regularly built at a spacing of 50 m along the approximately 6.3 km long stretch of the beach. Thus, 126 transects were built and attributed with ID ordered from west (transect ID 1) to east (transect ID 126) as described in Figure 27 and 28

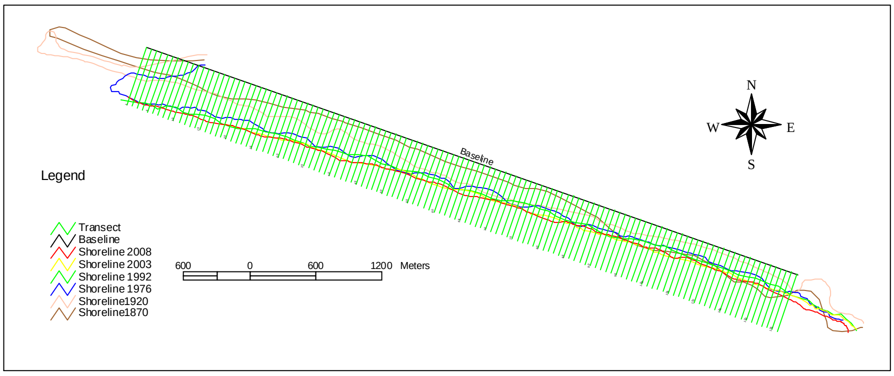


Figure 27. Cast Transects

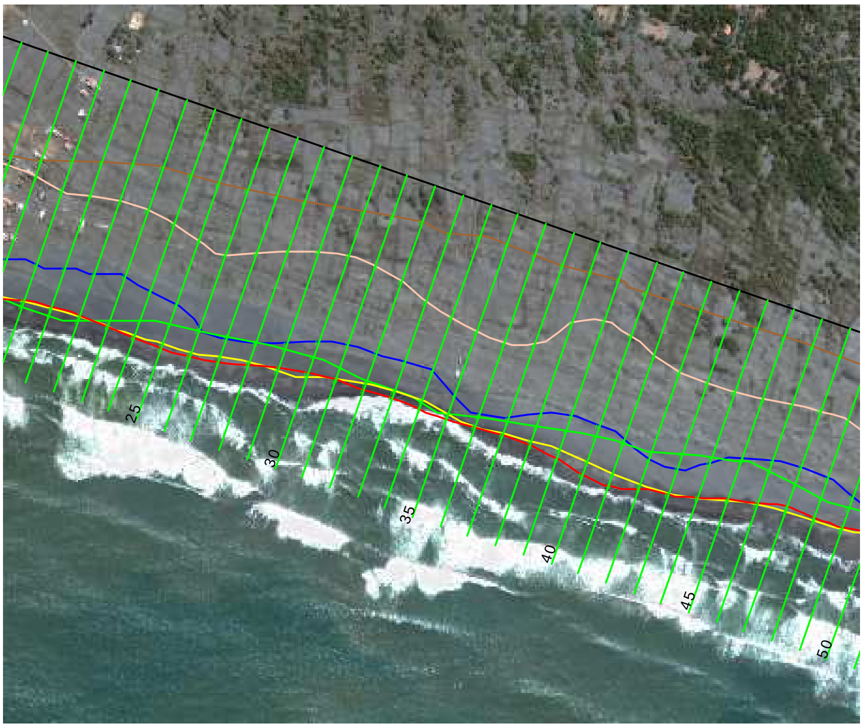


Figure 28. Detailed View of Cast Transects with Backdrop Image (Transect ID 20-47)

The first step in the analysis was quantify changes and change rate for each period of observation. Change rate was calculated using End Point Rate (EPR). The end point rate is calculated by dividing the distance of shoreline movement by the time elapsed between the earliest and latest measurements (i.e., the oldest and the most recent shoreline). Table 12. summarize changes and change rate for each period.

Table 12. Shoreline Changes and Change Rate for each Period

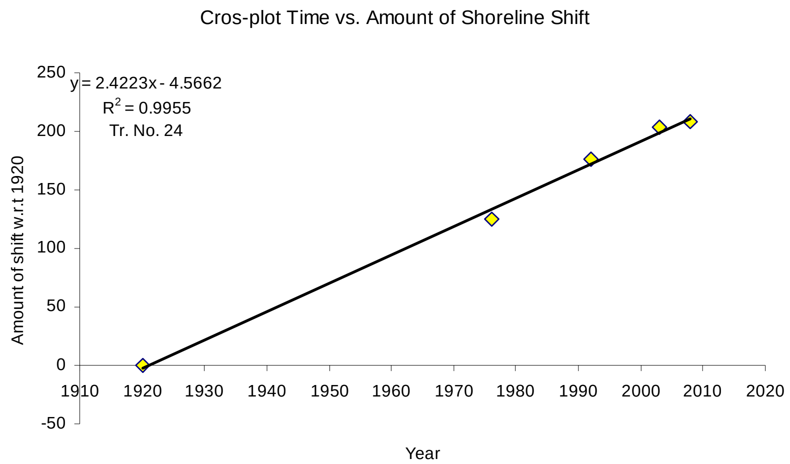
Period	1870 - 1920	1920 - 1976	1976 - 1992	1992 - 2003	2003 - 2008
Average changes (m)	33	97	200	32	5
change Rate (m/y)	1	2	1	3	1

Observing the average changes for 1870-1920, positional error estimation was exceeded the average changes, therefore the data was excluded from further analysis.

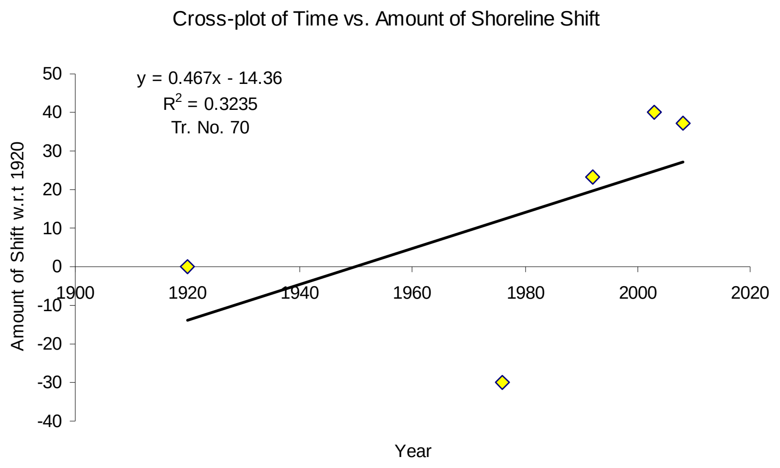
Longterm change rate was calculated using the Linear Regression Method (LRR). Linear regression was selected because it has been shown to be the most statistically robust quantitative method when a limited number of shorelines are available. It is also the most commonly applied statistical technique for expressing shoreline movement and estimating rates of change (Crowell *et al.* 1997) cited in (Honeycutt *et al.* 2003).

In Linear regression, rate-of-change statistic can be determined by fitting a least squares regression line to all shoreline points for a particular transect. The rate is the slope of the regression's line.

How fit is the line or the goodness of fit to the scatter plot, is measured by the "residual sum of square", i.e., Regression Coefficient (R^2) which has value ranging from 0 to 1. If all the values precisely match with the estimated trend, then R^2 would equal to 1, in the contrary, data without correlation would have R^2 of 0 as shown in Figure 29.



a. Cross-plot of time vs. amount of shoreline shift for transect no. 24



b. Cross-plot of time vs. amount of shoreline shift for transect no. 70

Figure 29. Cross-plot of Time vs. Amount of Shoreline Shift on Some Transects

R2 value vary spatially in each transect along the beach. Figure 30 shows that R^2 value is relatively high (between 0.8-1) in transect no. 1-56 corresponding to area near estuary and vicinity and in transect no. 81-126 which is influenced by anthropogenic activities (residential and tourism). In the contrary, low R^2 values (below 0.8) are observed from transect no. 57-80 which corresponding to rip current area. The distribution of R^2 value with the correspond area depicted in Figure 30 and 31.

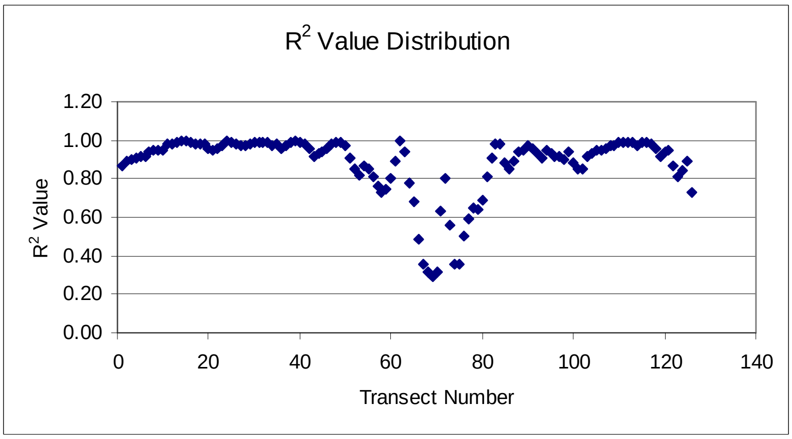
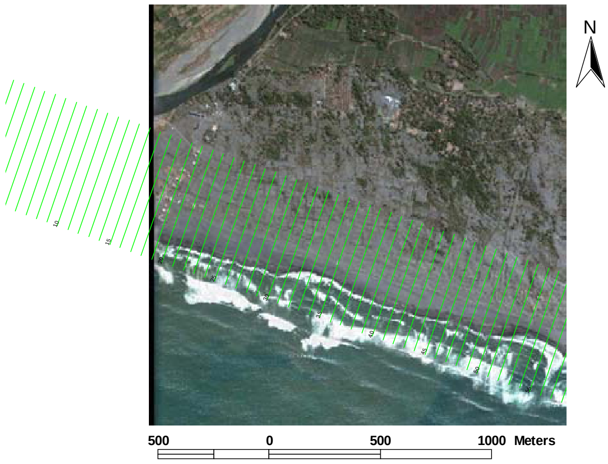
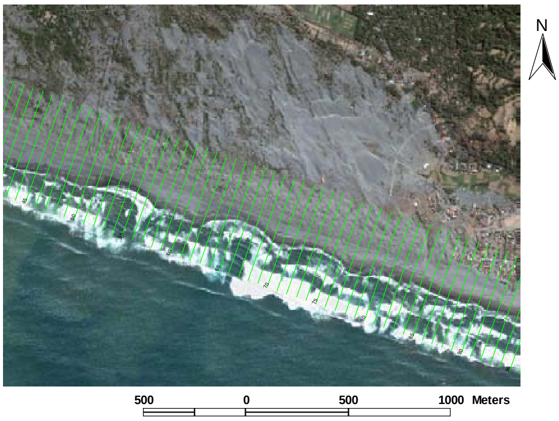


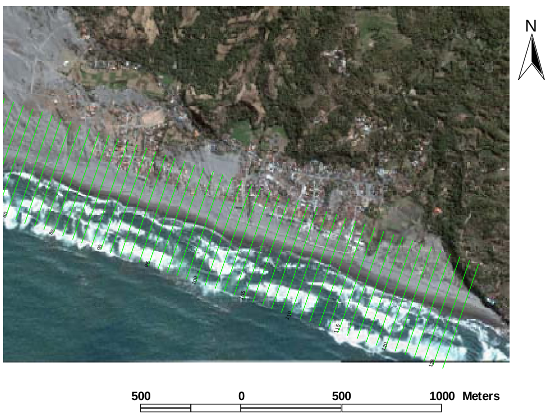
Figure 30. R^2 Value Of Each Transects



a. Area with high R^2 value, near to the estuary



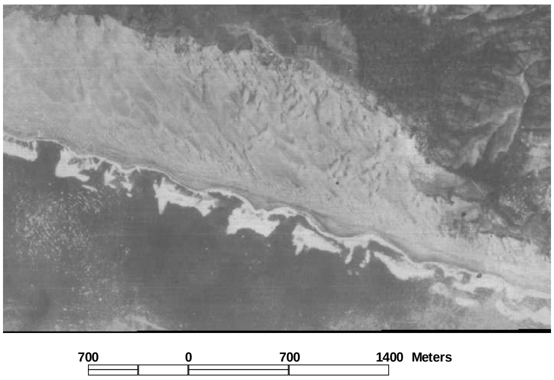
b. Area with low R^2 value, corresponding to rip current area.



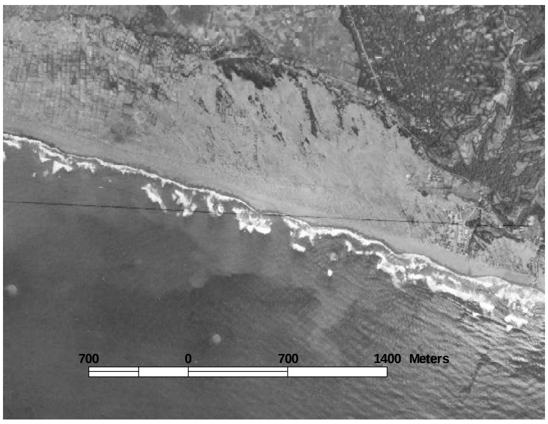
c. Area with high R^2 value, influenced by anthropogenic activities

Figure 31. Area With R^2 Value

R2 value indicated how many percent variance in Y (change rate) has been explained by variance in X (time). Based on this, section from transect no. 57 to transect no. 80 is considered highly dynamic. From aerial photographs it can be seen that in this area, cusp and bay often formed successively (see Figure 32).



1976



1992

2003

Figure 32. Highly Dynamic Section

Overall change rate based on linear regression and it's distribution along the beach is depicted in Figure 33.

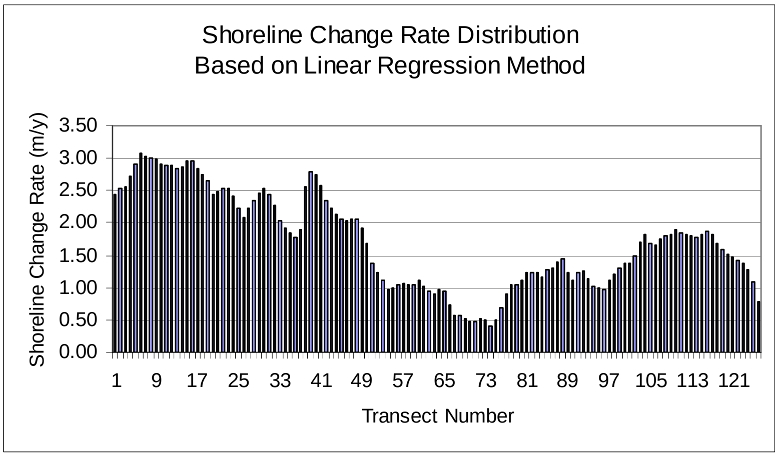


Figure 33. Shoreline Change Rate Distribution Graph Based On Linear Regression Method For Each Transects

Based on R^2 value, Parangtritis beach can be distinguished into 3 sections. In which their statistic parameter depicted below :

Table 13. Statistic Parameter For Each Section Of The Beach Based On R^2 Value

Statistic Parameter	Tr. 1-56	Tr. 57-80	Tr. 81-126
Total Number of Transect	56	24	46
Mean rate shoreline change rate (m/yr)	2.32	0.62	1.44
Minimum rate shoreline change rate (m/yr)	0.98	0.29	0.78
Maximum rate shoreline change rate (m/yr)	3.07	1.00	1.89
Standard deviation of rates (m/yr)	0.5	0.2	0.3
Total transect that record erosion	0	0	0
Total transect that record accretion	56	24	46
Total transect that record statistical uncertainty (R^2<0.8)	0	19	1

Comparing statistic parameter for each area, it can be seen that area of transect no. 1-57 has the highest change rate as well as highest standar deviation. This means that change rate vary among them. This is indicate that the area is influenced very much by sediment supply from the Opak river. The area of transect no. 57-80 shows lowest value of change rate and standard deviation comparing to the other. This indicates a constant movement of the sediment due to longshore current and rip current. The area of transect no. 81-126 indicates high shoreline change rate but low standard deviation. It could be that the area is affected by longshore current from the west but less affected by longshore current from the southeast.

In general, the dominant process in Parangtritis is accretion. The summary of Linear Regression Method to assess shoreline changes in Parangtritis is given below :

Total Number of Transect	: 126
Shoreline Length (km)	: 6.7
Mean rate shoreline change rate (m/yr)	: 1.7
Minimum rate shoreline change rate (m/yr)	: 0.4
Maximum rate shoreline change rate (m/yr)	: 3
Standard deviation of rates (m/yr)	: 0.7
Total transect that record erosion	: 0
Total transect that record accretion	: 126
Total transect that record statistical uncertainty (R2<0.8)	: 20

In order to understand the dynamic changes and change rate for each period of observation, change and change rate calculated using End Point Rate (EPR) were analyzed.

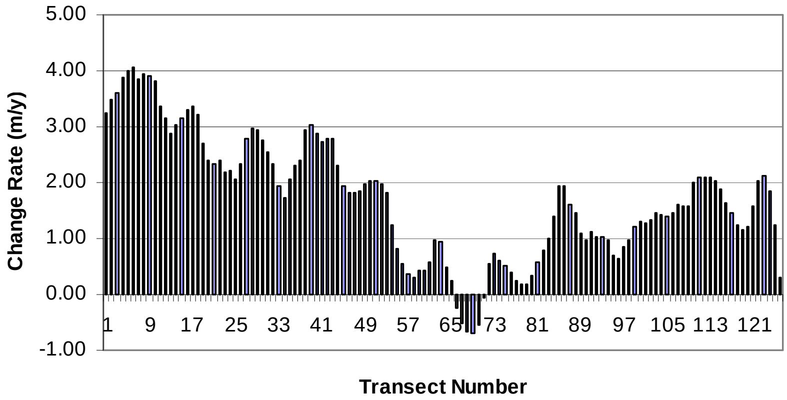


Figure 34. Shoreline Changes In The Period Of 1920-1976

During 1920 - 1976, shoreline change was accreting in the magnitude of 2 m/y. Most of the transect shows accretion process while retreating process was observed in transect no. 66-71. High magnitude accretion process up to

4 m/y were occur at the transect no. 1 – 50 which correspond to area near the inlet.

During this period, some storms and high waves have been reported to be happen i.e. in 1951, 1963 and 1972 (Singagarda 1991). Overall trend of accreting might be due to the dominance processes of sedimentation delivered by Opak River.

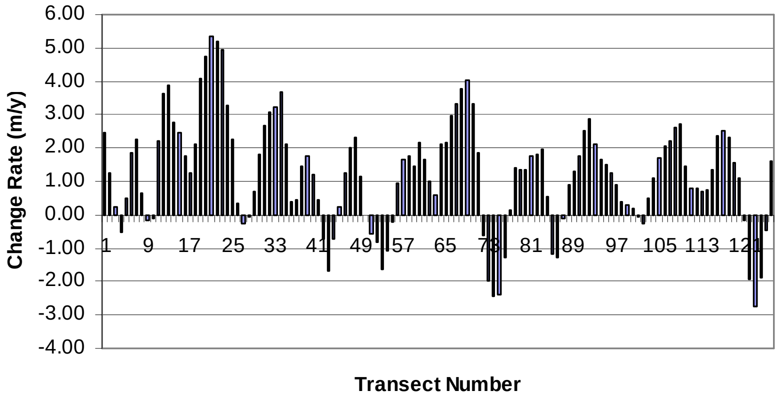


Figure 35. Shoreline Changes In The Period Of 1976 - 1992

During 1976-1992 period, shoreline change was in the magnitude of 1 m/y relative low comparing to that of 1920-1976. Although still shows accretion trend, several areas have been retreating. Storm and high wave have been reported to damaged Parangkusumo area at 1987 (Singagarda 1991). Started from 1980, Sabo Dam has been built in the up stream to reduce lahar hazard of Merapi Volcano. Considering that the material being deposited in Parangtritis beach is delivered by Opak River, reducing amount of sediment in Opak River could affect shoreline change rate.

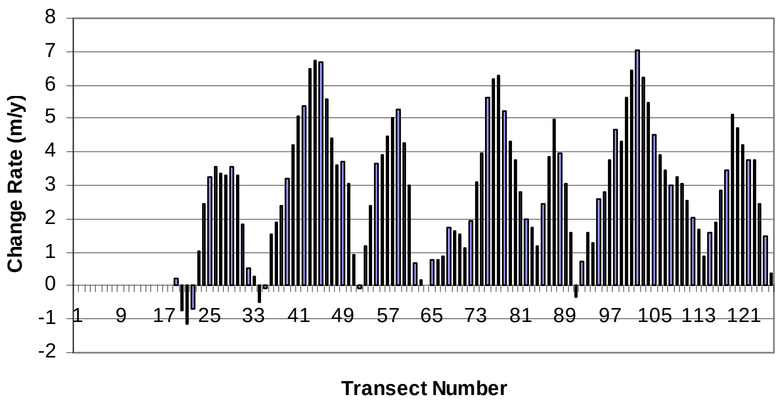


Figure 36. Shoreline Changes In The Period Of 1992 – 2003

During 1992-2003 period, shoreline change was in the magnitude of 3 m/y relative high comparing to both previous period. High magnitude of shoreline change could be attributed to the fact that during 1994 – 2001 yearly rainfall has increased. Increasing rainfall can be attributed to river flood occurrence.

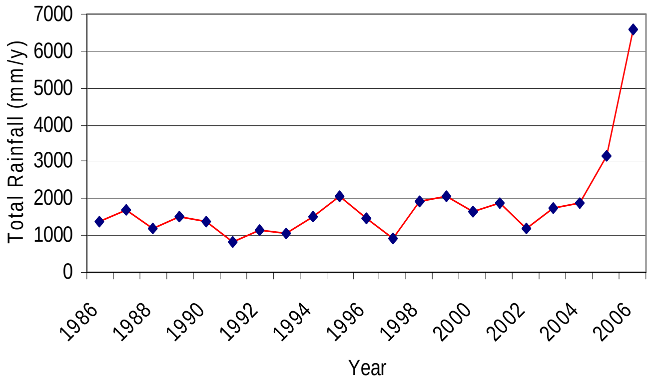


Figure 37 Yearly Rainfall 1986 – 2006 Based On Barongan Climate Station

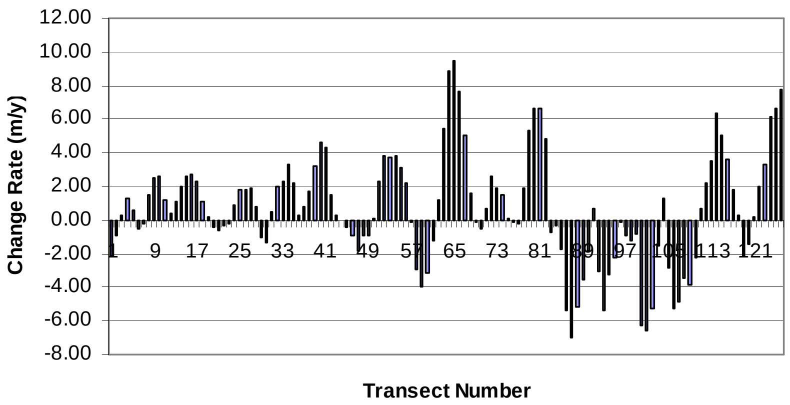


Figure 38. Shoreline Changes In The Period Of 2003 – 2008

During 2003-2008 period, shoreline change was in the magnitude of 1 m/y with overall trend was accreting. Retreating was observed in several transects and dominant in transect no. 83 – 110 which correspond to anthropogenic activities.

5.4.2 Shoreline Change Prediction

Future shoreline prediction was carried out by multiplying the rate of change with the desired time span. Prediction using historic change rate is assuming that underlying processes contribute to shoreline change has no significant alteration.

Before carrying out future shoreline prediction, it was necessary to assess the quality of prediction by means of back calculation. Back calculation was conducted by predicting past known shoreline position, and how close it with actual shoreline position is indicated by RMSE value.

Back calculation was using the most recent shoreline position i.e. shoreline position year 2008 as a baseline to back calculate 1992 and 1920 shoreline position. Two past known shoreline positions were chosen to represent short term and long term prediction model. Base on back calculation, RMSE for short term and long term were in the order of 30 and 10 m respectively. Spatial distribution of RMSE for both back calculation results could be found in Figure 39.

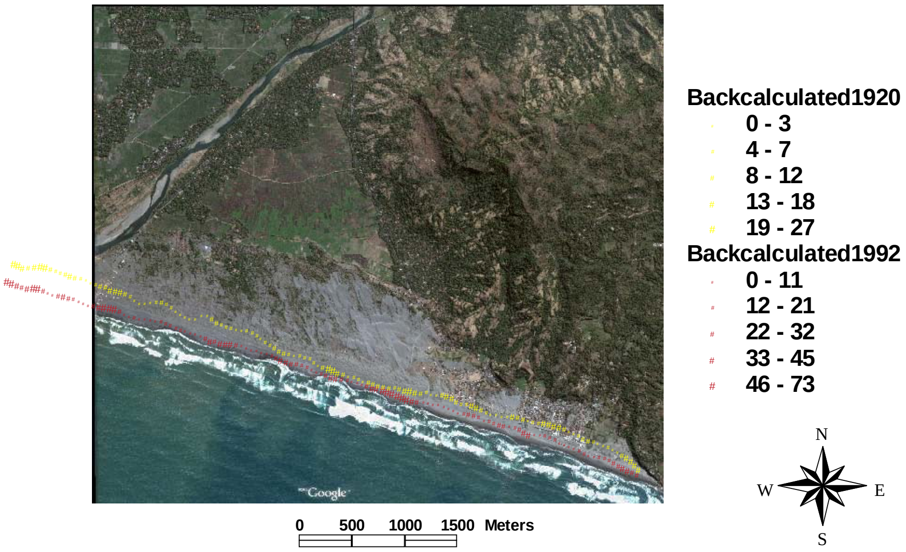


Figure 39. Back Calculation Of 1992 And 1920 Shoreline Position

Predicted shoreline position year 2018 and 2058 likely on average approximately to be 20 m and 100 m or less seaward from the recent shoreline (see map on Appendix 3.)

5.4.3 Effect Of Shoreline Change On Landuse Plan

According to Technical Plan of Parangtritis Tourism Resort Development 2002 (RTOW Parangtritis 2002), the area is divided into 8 zones. Prediction of shoreline position using Linear regression Method for year 2018 and 2058 indicated that accretion process is dominant in Parangtritis beach. This means that likely no infrastructure will be threatened by shoreline change in term of abrasion. Nevertheless, accretion process should be considered if a fishing port planned to be built in western part of Parangtritis since the area shows substantial accretion trend.

Observing 200 m and 300 m buffer zone which used by Local Government to restrict building development (see Figure 40.) although they based on

MHHWL, it not necessary to revise them along with the movement of shoreline seaward in the future. It would be better to keep the buffer zone in the recent status since they mainly established to avoid tsunami and high waves.

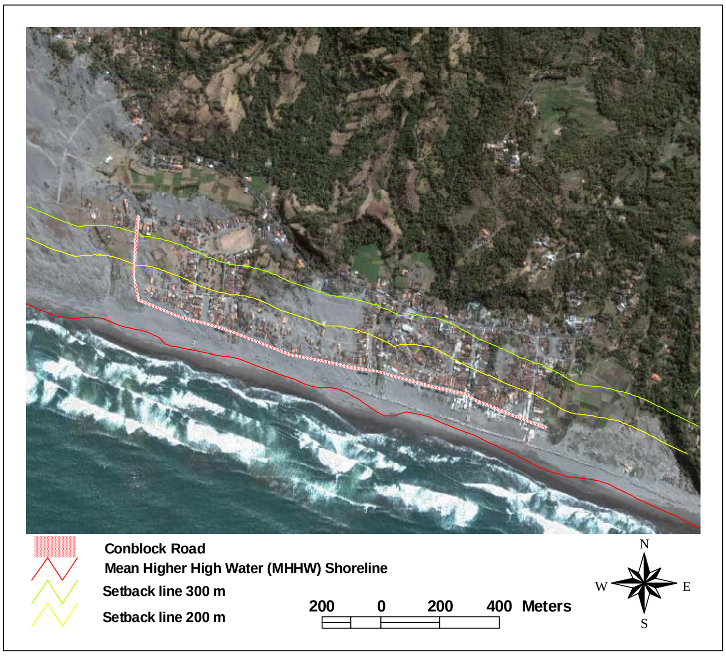


Figure 40. 200 m And 300 m Buffer Zone Based On MHHW Line

5.5. Landuse change assessment

5.5.1 Landuse Classification Used

Landuse classification used was adopted from Malingreau's classification to accommodate all type of landuses in the data source i.e. topographic map and aerial photograph. In Parangtritis, classification established as follow:

Table 14. Landuse Classification

Code	**Level 1**	**Code**	**Level 2**
K	Built up	*Kp*	*Settlement*
		Kk	*Cemetery*
S	Rice field	*Si*	*Irrigated rice field*
		Sr	*Rain fed rice field*
U	Upland crop	*Ut*	*Field crop*
		Uk	*Mixed garden*
D	Barren land	*Dg*	*Beaches*
		Dp	*Sand dune*
		Ds	*Sand bar*
W	Water bodies	*Wd*	*Lake*
		Ws	*Stream*
B	Bush/shrub	*Bb*	*Continuous thicket*
		Bs	*Scattered shrub*

5.5.2 Landuse Delineation

Landuse data sources were consisted of topographic map, aerial photograps and Quickbird image. Those data sources available in different scales and resolution. Dealing with different scales and resolution, delineation was carried out visually and plotted in the Quickbird image, taking advantage of it's high resolution. Figure 41 shows the plotting of sand dune from topographic map 1920 into Quickbird image in which it's remnant in rice field still recognized.

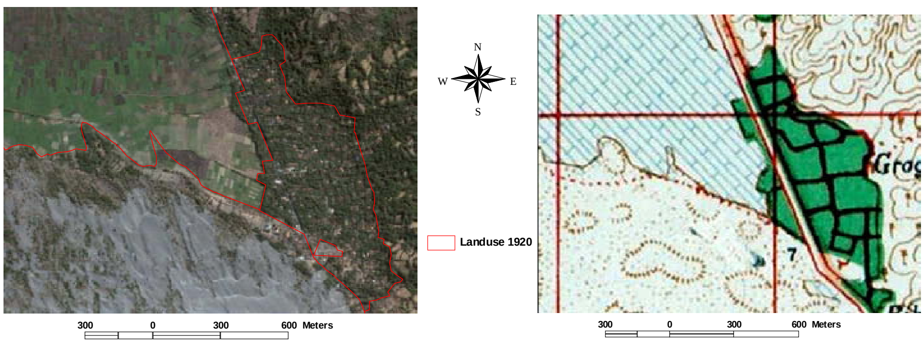


Figure 41. Landuse in Topographic Map 1920 Plotted in Quickbird Image

5.5.3 Landuse Change Detection

Landuse change detection was carried out using vector overlay method. The method required landuse vector map of each period (see Appendix 4). Once landuse classes for each period have been delineated, the overlay operation in term of union feature could be established. Based on the vector overlay method, landuse changes in Parangtritis were analyzed using level 1 classification (see Appendix 5.) This was done because landuse classes level 1 for topographic map 1920 namely barren land could not be divided further into level 2 namely beach and sand dune.

The result of landuse delineation is shown in the graph and table below.

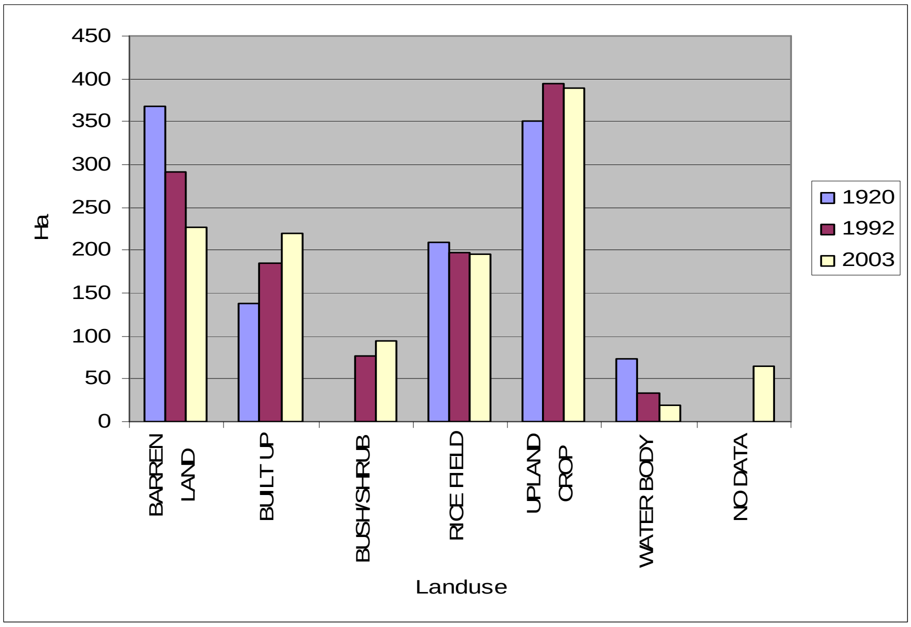


Figure 42. Land Use Change Graph

Table 15. Landuse Changes During 1920 - 2003

Level I	Level II	1920 (Ha)	1992 (Ha)	2003 (Ha)	Change 20-92 (Ha)	Change 92-03 (Ha)	Rate 20-92 (Ha/y)	Rate 92-03 (Ha/y)
Barren Land	Beaches Sand bar Sand dune	368.2	291.3	227.4	-76.9	-63.9	-1.1	-5.8
Built Up	Settlement Cemetery	138.0	184.8	220.5	46.8	35.7	0.6	3.2
Bush/ Shrub	Continuous thicket Scattered shrub		76.5	94.7	76.5	18.2	1.1	1.7
Rice Field	Irrigated rice field Rainfed rice field	208.9	197.5	195.7	-11.3	-1.8	-0.2	-0.2
Upland Crop	Field crop Mixed garden	350.5	394.5	388.8	44.0	-5.7	0.6	-0.5
Water Body	Stream Lake	72.6	32.7	19.5	-39.9	-13.2	-0.6	-1.2
No Data				64.1	0.0	64.1		

5.5.4 Discussion

During 1920-1992, built up class, upland crop class and bush/shrub class were increased. The most significant changes occurred to built up class which increased 46.8 ha or in the rate of 0.6 ha/year. Upland crop increased 44 ha or in the rate of 0.6 ha/year. Bush/shrub class seem to increase, but it was happen because for topographic map 1920, bush/shrub class could not be identified. This is one of the limitations of using topographic map, in which symbol represent features but not represent area.

Barren land class, water body and rice field classes were decreased. The most significant changes occurred to barren land class which was decreased about 76.9 ha or in the rate of 1.1 ha/year. Water body decreased 39.9 ha, and rice field decreased 11.3 ha.

The increased of the built up area class was along with the decreased of the barren land class and rice field class. The increase of the settlement, in fact occupied sand dunes and some rice fields thus decreasing those two classes. Beside caused by the encroachment of settlement, the decrease of barrend land also caused by upland crop class was increased by the alternation of sand dunes into field crop.

The interesting fact was that in fact, sand dune was also increased by encroaching and buried (see Figure 43) so the rice field class has decreased.

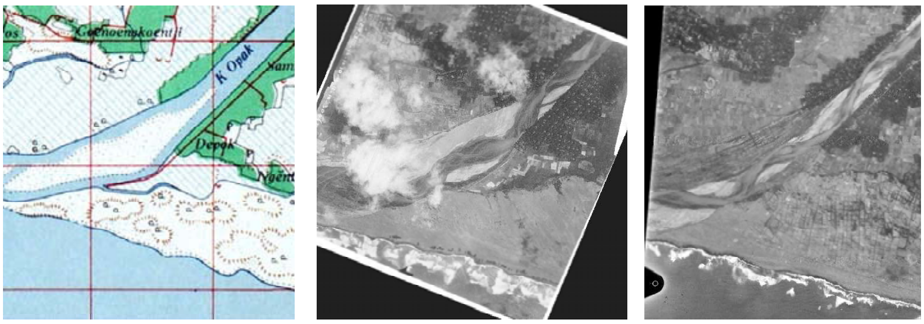


Figure 43. Landuse changes from sand dune class into upland crop class. Sand dune also buried irrigated rice field. 1920 (left), 1946 (middle), and 1992 (right).

Water body class was decreased due to sand bar class which changed into stream class and lake class that changed into rainfed rice field.

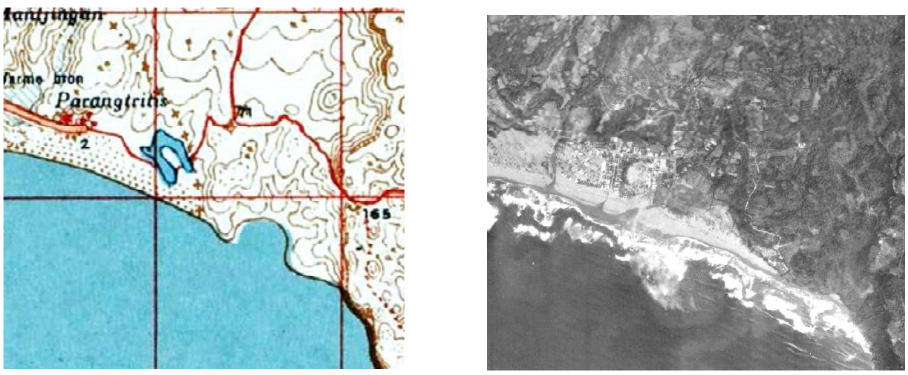


Figure 44. Lagoon Turned Into Rice Field.

During 1992-2003, increasing changes were still occurred to built up class which increased 35.7 ha or in the rate of 3.2 ha/year. The rate of change for built up area increasing significantly might be because of tourism activities.

In this period, the increased of built up still followed by the decrease of barren land class in the rate of 5.8 ha/year. The other classes, i.e.: rice field class, upland crop, and water body were also decreased.

Considering the fact that barren land class, particularly sand dune is the most affected landuse class by human activities in Parangtritis, the decision to preserve the existence of sand dune as depicted in Parangtritis Meso Scale Landuse Plan should be accompany by law enforcement. The establishment of buffer zone 300 m from highest high waterline decreased the area previously used by tourism activities. It might be, as a consequences, abandoned people from buffer zone will utilize sand dune which was stated as preserve zone.

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6. CONCLUSION AND RECOMENDATION

6.1. Conclusion

The recent study is aimed to assess coastal changes in Parangtritis, Yogyakarta by mean of Geographic Information System (GIS) using multi spatio-temporal geographic data in order to provide information for coastal spatial planning. The study is focused on an understanding of the Java South Coast characteristic particularly in Parangtritis beach, emphasizing shoreline and land-use changes using multi spatio-temporal data.

It can be concluded that the multi spatio data can be used to monitor and assess the coastal changes by taking advantages of GIS. However, the usage of small scale spatial data such as topographic map scale 1:100.000 should be used carefully, especially when dealing with area with relative small changes.

High resolution image such as Quickbird image can be use to dealing with scale difference by using it to plot the delineation from another spatial data sources due to it’s high resolution.

Another conclusion is that the coastal processes in Parangtritis beach is accretion in the magnitude of 1.70 m/y on average. Area affected by accretion process is beach preservation zone in which at the eastern part is corresponding to anthropogenic activities such as tourism, and in the western part is corresponding to inlet/river mouth.

Linear regression method used for predicting shoreline position show the difference value of RMSE for long term and short term prediction with high RMSE for short term prediction. Predicted shoreline position year 2018 and 2058 likely on average approximately to be 20 m and 100 m or less seaward from the recent shoreline.

The most rapid landuse changes in Parangtritis is built up class. This is due to the tourism activities. The most affected landuse class by tourism activities in Parangtritis is barren land, particularly sand dune class. Rice field changed but not significant, showed the importance of agriculture for Parangtritis residents.

6.2. Recomendation

In order to monitor changes in the coastal area, multi-spatio temporal data can be used to overcome the lack of data availability with regard to scale differences.

To assess shoreline change and change rate used to predict future shoreline position, it is recommended to use method that accommodate the dynamic nature of shoreline changes in term of cyclic or non linear movement to obtain real change rate.

Coastal processes that dominated by accretion processes should be taken into account in the establishment of coastal structure, and it is not necessary followed by the adjustment of buffer zone, especially when it is mainly to mitigate tsunami hazard and high waves.

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Appendix 1. Annual Surface Current Pattern

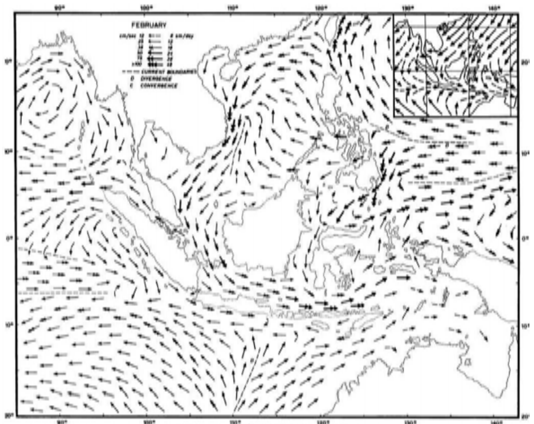


Plate 1. a. Surface currents in February.

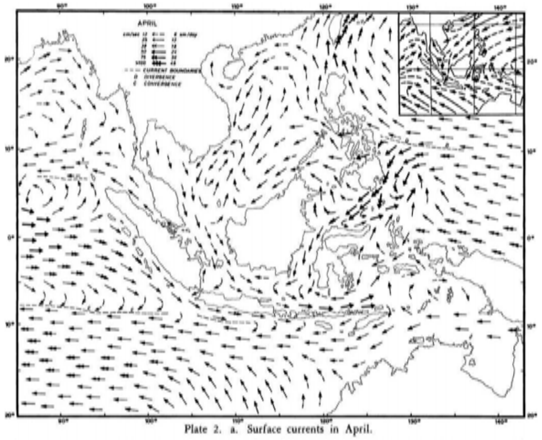


Plate 2. a. Surface currents in April.

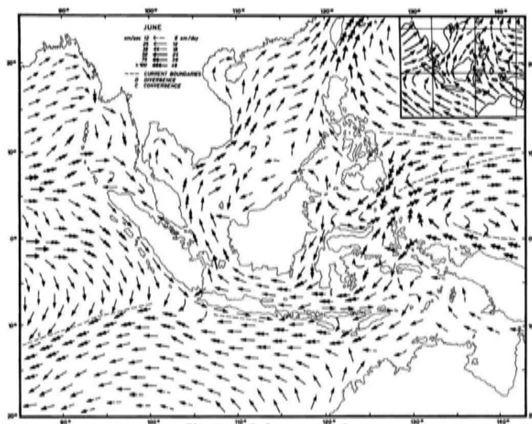


Plate 3. a. Surface currents in June.

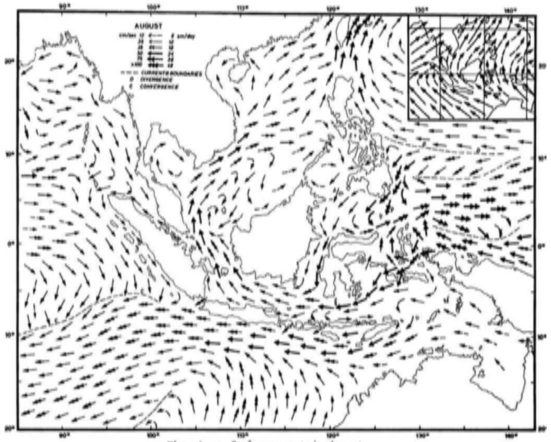


Plate 4. a. Surface currents in August.

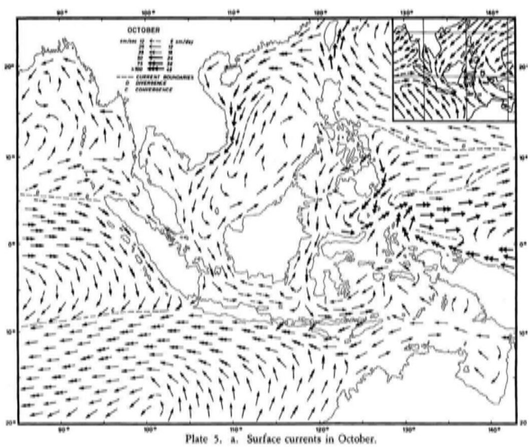


Plate 5. a. Surface currents in October.

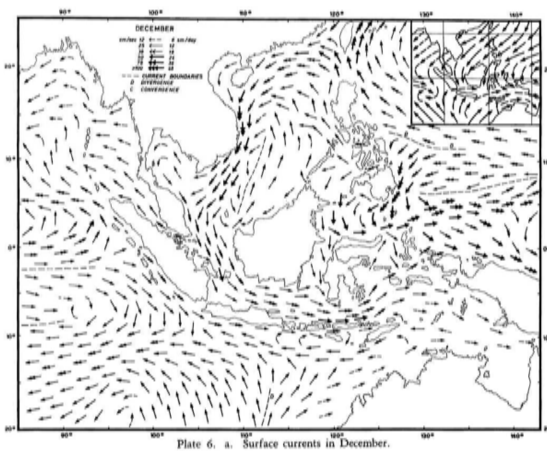
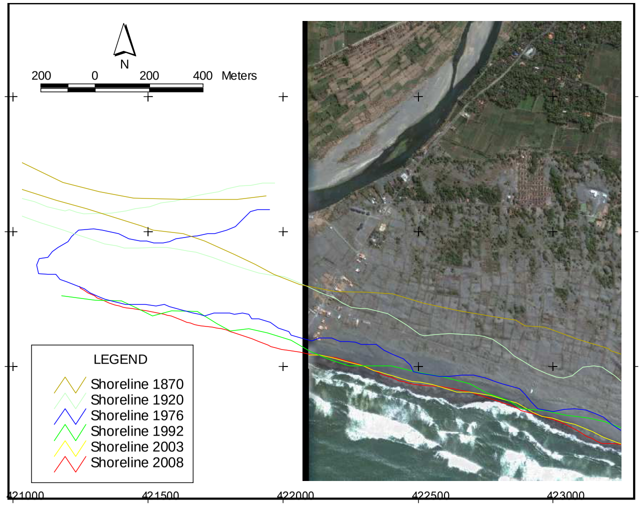
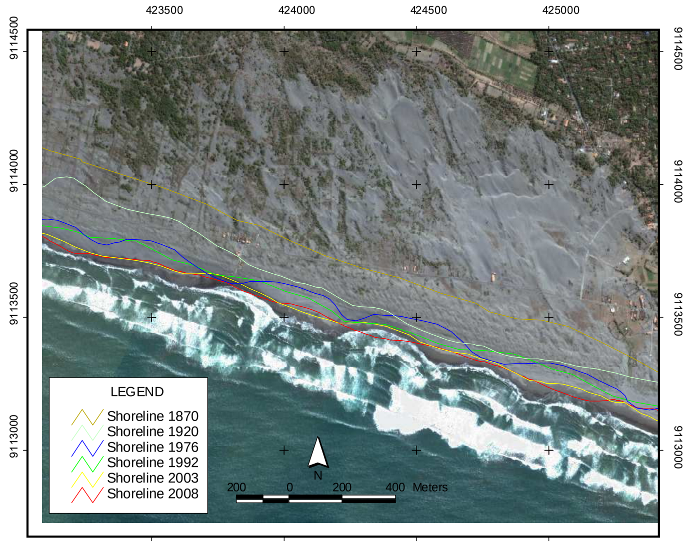


Plate 6. a. Surface currents in December.

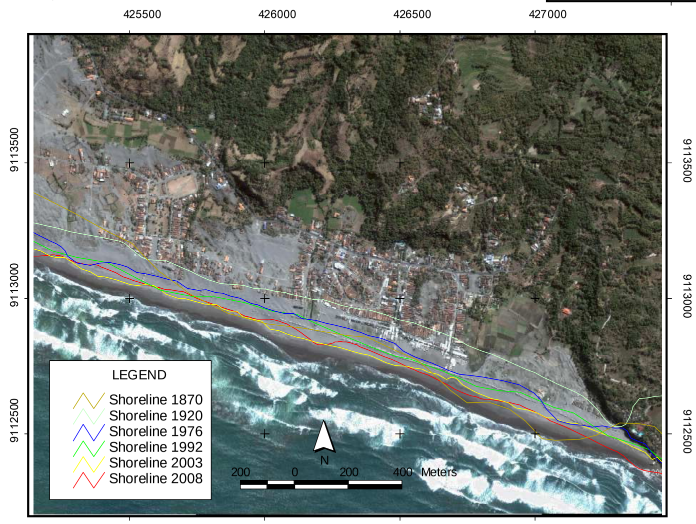
Appendix 2. Map of Shoreline Position During 1870 - 2008



a. Western Part

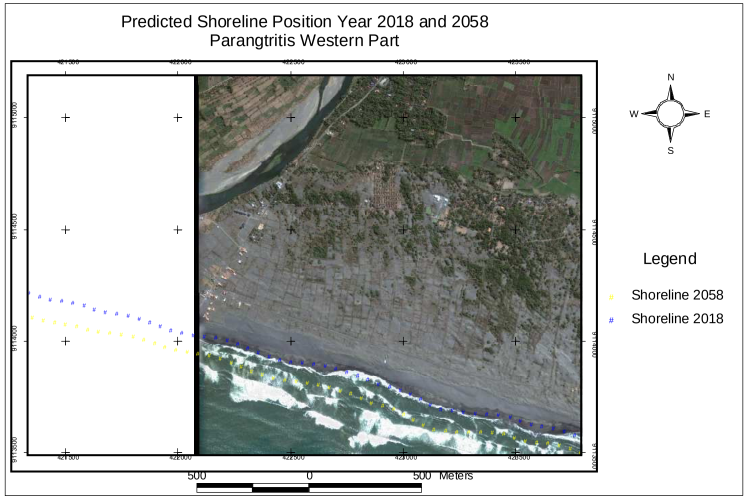


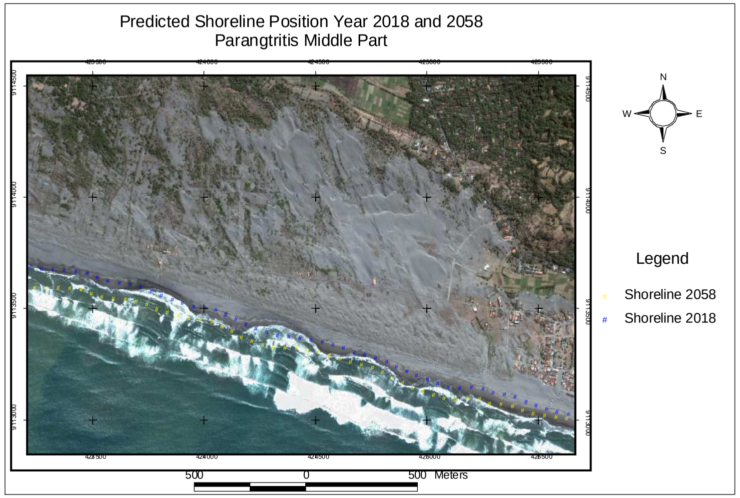
b. Middle Part

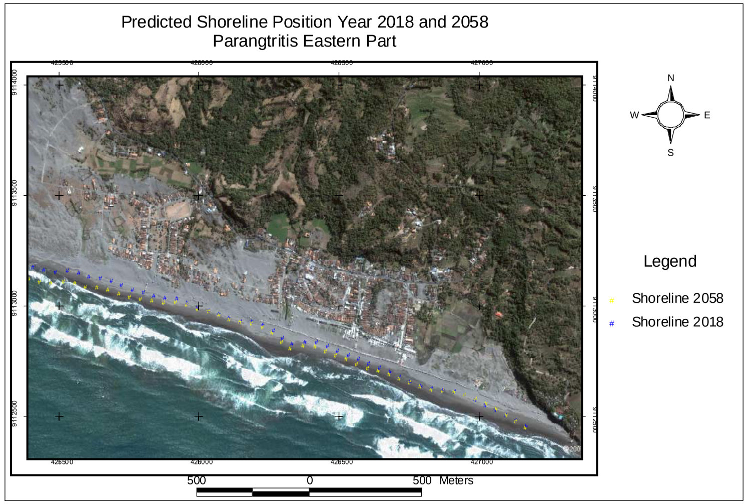


c. Eastern Part

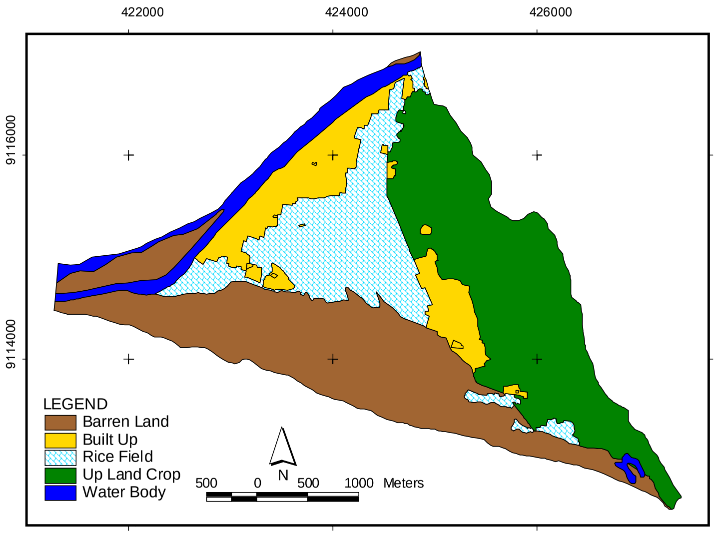
Appendix 3. Map of Predicted Shoreline Position Year 2018 and 2058



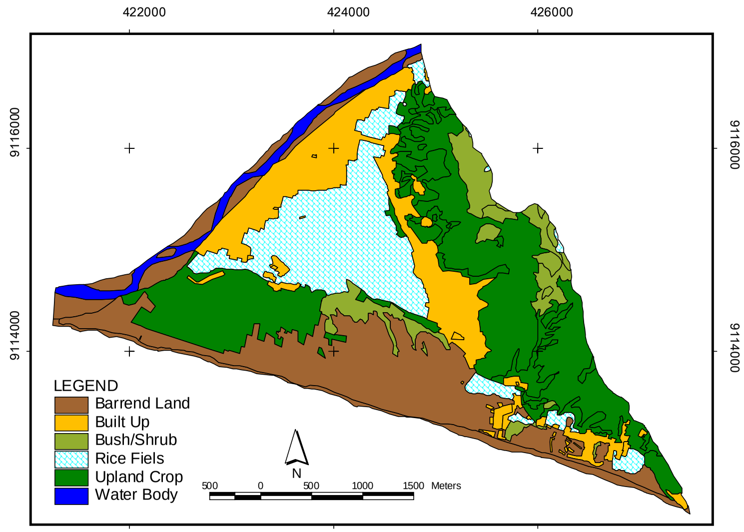




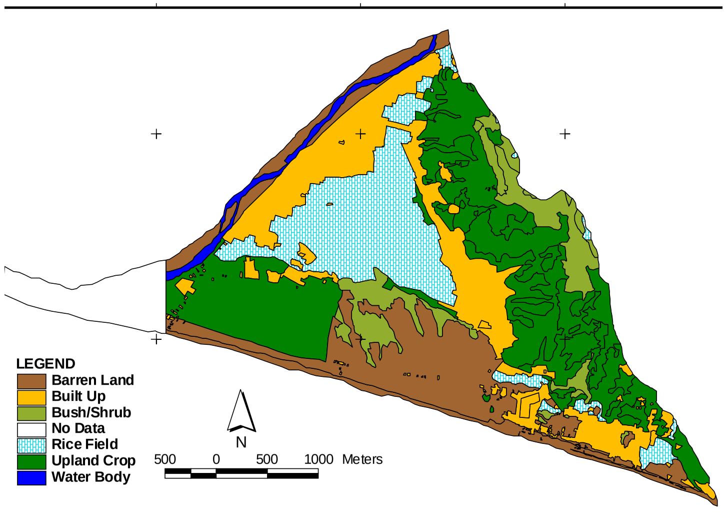
Appendix 4. Landuse Map



a. Landuse 1920

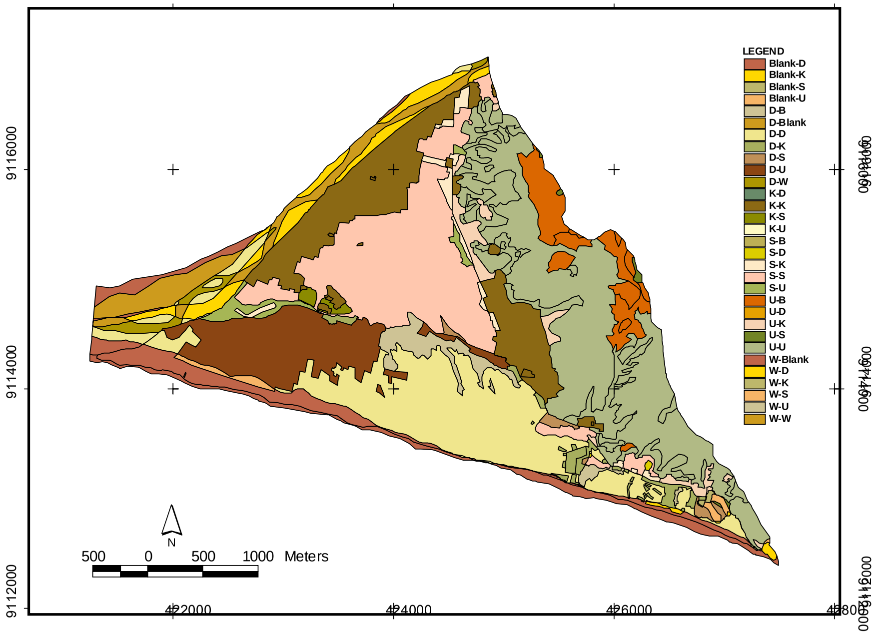


b. Landuse 1992

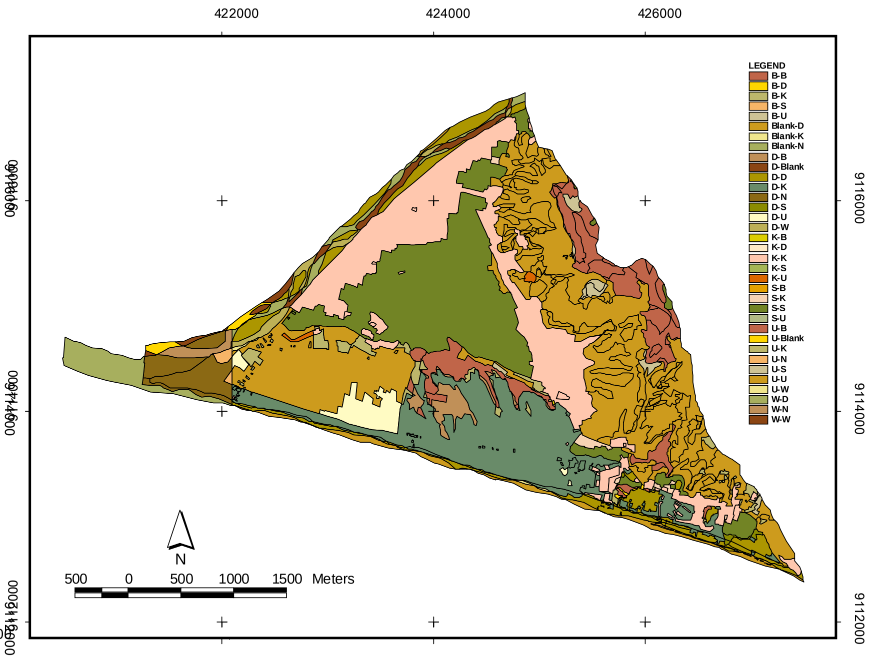


c. Landuse 2003

Appendix 5. Landuse Change Maps



a. 1920 – 1992



b. 1992 - 2003

Appendix 6. Detailed transect wise description of shoreline change rate (m/yr), Regression Coeficient Value (R^2), 1992 and 1920 year back calculated RMS error, predicted henceforth 10 and 50 year shoreline position and geomorphological characteristic

Tr. No	Shoreline Change Rate (m/yr)	R^2	Back calculated RMS Error (m)		Future Prediction (m)		Geo morphological Characteristic
			1992	1920	2018	2058	
1	2.43	0.87	72.94	26.99	24.3	121.5	Near inlet, coarsest grain size, backed by low dune
2	2.52	0.89	55.34	21.42	25.2	126	
3	2.55	0.90	36.82	14.63	25.5	127.5	
4	2.73	0.91	23.59	10.29	27.3	136.5	
5	2.92	0.92	37.22	15.22	29.2	146	
6	3.07	0.92	57.19	21.51	30.7	153.5	
7	3.03	0.94	52.46	19.35	30.3	151.5	
8	3.00	0.95	24.51	10.52	30	150	
9	2.97	0.95	6.96	4.11	29.7	148.5	
10	2.92	0.95	5.47	4.00	29.2	146	
11	2.88	0.98	26.20	10.08	28.8	144	
12	2.89	0.98	40.45	14.49	28.9	144.5	
13	2.83	0.99	28.27	9.50	28.3	141.5	
14	2.87	1.00	13.38	5.01	28.7	143.5	
15	2.96	1.00	5.88	2.41	29.6	148	
16	2.95	0.99	3.14	2.09	29.5	147.5	
17	2.84	0.98	8.24	4.14	28.4	142	
18	2.74	0.98	25.86	9.72	27.4	137	
19	2.64	0.98	38.71	11.71	26.4	132	
20	2.44	0.96	49.35	14.99	24.4	122	
21	2.48	0.95	55.27	17.00	24.8	124	
22	2.54	0.96	49.60	14.71	25.4	127	
23	2.54	0.97	30.21	11.63	25.4	127	
24	2.42	1.00	7.01	4.54	24.2	121	
25	2.23	0.99	9.24	0.42	22.3	111.5	
26	2.07	0.98	15.05	3.14	20.7	103.5	
27	2.22	0.97	10.88	3.20	22.2	111	
28	2.33	0.97	3.30	0.43	23.3	116.5	
29	2.45	0.98	5.12	5.76	24.5	122.5	
30	2.52	0.99	10.43	8.13	25.2	126	
31	2.44	0.99	16.27	6.61	24.4	122	
32	2.27	0.99	20.52	4.48	22.7	113.5	
33	2.03	0.99	17.79	2.87	20.3	101.5	
34	1.91	0.97	19.10	1.81	19.1	95.5	

35	1.84	0.98	19.07	1.91	18.4	92	
36	1.78	0.96	10.29	2.78	17.8	89	
37	1.90	0.97	5.36	1.48	19	95	
38	2.56	0.99	5.85	1.49	25.6	128	
39	2.80	1.00	6.53	3.07	28	140	
40	2.74	0.99	25.50	9.09	27.4	137	
41	2.58	0.98	36.46	10.54	25.8	129	
42	2.34	0.96	28.85	5.44	23.4	117	
43	2.23	0.92	37.36	5.60	22.3	111.5	
44	2.13	0.93	39.94	4.40	21.3	106.5	
45	2.06	0.94	38.44	2.41	20.6	103	
46	2.04	0.96	24.11	1.03	20.4	102	
47	2.05	0.98	6.59	6.54	20.5	102.5	
48	2.05	0.99	2.18	5.39	20.5	102.5	
49	1.91	0.99	5.62	3.61	19.1	95.5	
50	1.67	0.97	7.13	0.34	16.7	83.5	
51	1.38	0.91	0.06	4.39	13.8	69	
52	1.24	0.85	1.66	6.76	12.4	62	
53	1.11	0.82	13.72	9.62	11.1	55.5	
54	0.98	0.87	29.83	11.60	9.8	49	
55	1.00	0.85	40.19	10.69	10	50	
56	1.05	0.81	37.19	7.41	10.5	52.5	
57	1.06	0.76	31.60	1.57	10.6	53	Steeper slope, coarser grain, backed by dune, rip current area
58	1.04	0.73	24.25	5.01	10.4	52	
59	1.05	0.75	21.23	6.78	10.5	52.5	
60	1.10	0.80	13.14	7.47	11	55	
61	1.02	0.89	10.55	3.84	10.2	51	
62	0.94	1.00	2.03	0.25	9.4	47	
63	0.91	0.94	14.55	11.14	9.1	45.5	
64	0.98	0.78	28.93	18.57	9.8	49	
65	0.94	0.68	40.91	21.03	9.4	47	
66	0.73	0.49	35.03	16.32	7.3	36.5	
67	0.57	0.36	25.93	9.47	5.7	28.5	
68	0.56	0.32	18.13	1.50	5.6	28	
69	0.52	0.29	8.90	3.57	5.2	26	
70	0.47	0.32	6.52	4.21	4.7	23.5	
71	0.47	0.63	8.43	0.49	4.7	23.5	
72	0.53	0.80	25.94	8.90	5.3	26.5	
73	0.49	0.56	36.05	10.60	4.9	24.5	
74	0.40	0.36	44.77	11.21	4	20	
75	0.49	0.36	54.67	9.50	4.9	24.5	
76	0.69	0.50	56.66	8.38	6.9	34.5	
77	0.89	0.59	53.42	6.12	8.9	44.5	
78	1.04	0.65	49.89	8.09	10.4	52	

79	1.03	0.64	57.73	15.95	10.3	51.5	
80	1.10	0.69	57.13	18.58	11	55	
81	1.22	0.81	44.76	16.75	12.2	61	Relative flat slope, fine sand, intermitten inlet, antropogenic activities (tourism), backed by high dune
82	1.24	0.91	25.82	9.89	12.4	62	
83	1.22	0.98	4.10	4.77	12.2	61	
84	1.16	0.98	7.26	3.17	11.6	58	
85	1.27	0.88	2.16	3.37	12.7	63.5	
86	1.31	0.85	5.17	10.79	13.1	65.5	
87	1.40	0.89	2.51	14.75	14	70	
88	1.44	0.94	4.98	12.95	14.4	72	
89	1.23	0.95	3.86	9.82	12.3	61.5	
90	1.11	0.97	9.53	7.39	11.1	55.5	
91	1.23	0.96	20.28	5.51	12.3	61.5	
92	1.26	0.93	27.47	13.92	12.6	63	
93	1.13	0.91	27.61	17.18	11.3	56.5	
94	1.02	0.95	18.67	11.58	10.2	51	
95	0.99	0.93	1.70	6.27	9.9	49.5	
96	0.98	0.92	14.16	0.09	9.8	49	
97	1.12	0.92	18.85	0.68	11.2	56	
98	1.21	0.90	25.93	0.30	12.1	60.5	
99	1.30	0.94	22.06	0.01	13	65	
100	1.36	0.88	8.38	12.82	13.6	68	
101	1.37	0.85	16.30	11.33	13.7	68.5	
102	1.48	0.85	27.64	7.56	14.8	74	
103	1.71	0.92	33.41	0.02	17.1	85.5	
104	1.81	0.93	37.68	4.89	18.1	90.5	
105	1.67	0.95	8.67	7.12	16.7	83.5	
106	1.65	0.95	9.94	15.33	16.5	82.5	
107	1.76	0.96	14.13	15.03	17.6	88	
108	1.80	0.97	13.25	13.06	18	90	
109	1.83	0.97	12.80	13.79	18.3	91.5	
110	1.89	0.99	8.05	8.76	18.9	94.5	
111	1.84	0.99	2.17	0.64	18.4	92	
112	1.82	0.99	3.94	2.06	18.2	91	
113	1.80	0.99	7.37	5.72	18	90	
114	1.77	0.97	12.81	11.85	17.7	88.5	
115	1.82	0.99	13.44	8.41	18.2	91	
116	1.86	0.99	8.92	4.59	18.6	93	
117	1.83	0.98	11.05	0.57	18.3	91.5	
118	1.69	0.96	12.55	1.56	16.9	84.5	
119	1.59	0.92	20.08	4.57	15.9	79.5	
120	1.51	0.94	20.44	2.09	15.1	75.5	
121	1.47	0.95	23.57	2.86	14.7	73.5	
122	1.42	0.87	28.54	8.73	14.2	71	

123	1.37	0.81	36.10	12.87	13.7	68.5	
124	1.28	0.84	37.05	17.72	12.8	64	
125	1.08	0.89	32.05	16.46	10.8	54	
126	0.78	0.73	30.41	16.87	7.8	39	

Appendix 7. Detailed transect wise description of shoreline change rate (m/yr), For Each Period Using End Point Rate and Overal Change Rate Using Linear Regression

Tr. No.	1920-1976	1976-1992	1992-2003	2003-2008	LRR
1	3.23	2.49	*n/a*	-2.13	2.43
2	3.48	1.26	*n/a*	-0.94	2.52
3	3.61	0.23	*n/a*	0.25	2.55
4	3.89	-0.51	*n/a*	1.25	2.73
5	4.01	0.49	*n/a*	0.59	2.92
6	4.05	1.87	*n/a*	-0.50	3.07
7	3.84	2.27	*n/a*	-0.25	3.03
8	3.93	0.62	*n/a*	1.47	3.00
9	3.91	-0.17	*n/a*	2.53	2.97
10	3.81	-0.13	*n/a*	2.58	2.92
11	3.36	2.21	*n/a*	1.24	2.88
12	3.14	3.63	*n/a*	0.36	2.89
13	2.87	3.86	*n/a*	1.06	2.83
14	3.04	2.79	*n/a*	2.03	2.87
15	3.16	2.48	*n/a*	2.59	2.96
16	3.30	1.78	*n/a*	2.75	2.95
17	3.37	1.24	*n/a*	2.32	2.84
18	3.20	2.13	*n/a*	1.12	2.74
19	2.70	4.09	0.25	0.16	2.64
20	2.40	4.72	-0.75	-0.41	2.44
21	2.34	5.34	-1.12	-0.64	2.48
22	2.41	5.18	-0.66	-0.33	2.54
23	2.18	4.95	1.05	-0.24	2.54
24	2.22	3.25	2.46	0.93	2.42
25	2.06	2.28	3.27	1.78	2.23
26	2.34	0.36	3.54	1.83	2.07
27	2.78	-0.24	3.36	1.88	2.22
28	2.96	-0.06	3.31	0.83	2.33
29	2.94	0.69	3.54	-0.99	2.45
30	2.77	1.79	3.32	-1.34	2.52
31	2.55	2.66	1.86	0.45	2.44
32	2.32	3.09	0.55	1.95	2.27
33	1.95	3.23	0.27	2.34	2.03
34	1.72	3.65	-0.48	3.35	1.91
35	2.07	2.12	-0.08	2.25	1.84
36	2.31	0.38	1.54	0.24	1.78
37	2.38	0.45	1.91	0.81	1.90
38	2.95	1.47	2.42	1.70	2.56

Rates were calculated from shoreline 1992-2008 due to the unavailability of s.l at this segment

39	3.03	1.77	3.19	3.24	2.80
40	2.88	1.20	4.20	4.61	2.74
41	2.73	0.44	5.08	4.36	2.58
42	2.79	-0.72	5.35	1.48	2.34
43	2.78	-1.67	6.49	0.32	2.23
44	2.31	-0.72	6.74	-0.04	2.13
45	1.94	0.22	6.68	-0.43	2.06
46	1.81	1.26	5.57	-0.91	2.04
47	1.82	2.02	4.41	-1.84	2.05
48	1.84	2.32	3.60	-0.93	2.05
49	1.96	1.17	3.70	-0.90	1.91
50	2.02	-0.03	3.06	0.04	1.67
51	2.02	-0.59	0.94	2.35	1.38
52	1.98	-0.82	-0.07	3.79	1.24
53	1.82	-1.63	1.18	3.69	1.11
54	1.25	-1.10	2.39	3.85	0.98
55	0.82	-0.20	3.68	3.14	1.00
56	0.54	0.97	3.89	2.22	1.05
57	0.36	1.64	4.49	-0.16	1.06
58	0.31	1.75	5.04	-2.92	1.04
59	0.43	1.47	5.26	-3.97	1.05
60	0.43	2.15	4.25	-3.20	1.10
61	0.59	1.64	3.00	-1.22	1.02
62	0.96	0.98	0.65	1.16	0.94
63	0.95	0.57	0.17	5.45	0.91
64	0.47	2.11	0.03	8.86	0.98
65	0.24	2.16	0.77	9.48	0.94
66	-0.25	2.97	0.75	7.68	0.73
67	-0.51	3.32	0.88	5.08	0.57
68	-0.66	3.80	1.76	1.55	0.56
69	-0.70	4.01	1.62	-0.13	0.52
70	-0.54	3.32	1.53	-0.55	0.47
71	-0.06	1.84	1.13	0.71	0.47
72	0.56	-0.63	1.92	2.66	0.53
73	0.74	-1.98	3.10	1.94	0.49
74	0.62	-2.46	3.98	1.48	0.40
75	0.51	-2.40	5.63	0.10	0.49
76	0.38	-1.25	6.19	-0.10	0.69
77	0.25	0.16	6.27	-0.26	0.89
78	0.19	1.40	5.20	1.85	1.04
79	0.19	1.36	4.30	5.37	1.03
80	0.34	1.35	3.76	6.66	1.10
81	0.56	1.76	2.82	6.65	1.22
82	0.80	1.80	1.97	4.79	1.24

83	0.99	1.97	1.75	-0.76	1.22
84	1.41	0.55	1.20	-0.37	1.16
85	1.94	-1.15	2.44	-1.73	1.27
86	1.95	-1.29	3.86	-5.34	1.31
87	1.61	-0.11	4.98	-6.99	1.40
88	1.45	0.90	3.98	-5.14	1.44
89	1.10	1.31	3.07	-3.58	1.23
90	0.96	1.77	1.59	-1.84	1.11
91	1.13	2.51	-0.36	0.67	1.23
92	1.04	2.89	0.70	-3.01	1.26
93	1.04	2.09	1.60	-5.42	1.13
94	0.96	1.67	1.26	-3.25	1.02
95	0.70	1.52	2.60	-2.22	0.99
96	0.64	1.26	2.78	-0.15	0.98
97	0.84	0.89	3.76	-0.91	1.12
98	0.98	0.39	4.65	-1.19	1.21
99	1.20	0.27	4.29	-0.87	1.30
100	1.32	0.19	5.60	-6.31	1.36
101	1.28	-0.04	6.44	-6.54	1.37
102	1.35	-0.26	7.04	-5.22	1.48
103	1.46	0.49	6.22	-1.55	1.71
104	1.42	1.12	5.47	1.29	1.81
105	1.38	1.68	4.51	-2.85	1.67
106	1.44	2.04	3.90	-5.30	1.65
107	1.61	2.22	3.48	-4.85	1.76
108	1.57	2.62	3.00	-3.50	1.80
109	1.56	2.70	3.23	-3.81	1.83
110	1.99	1.48	3.03	-2.24	1.89
111	2.08	0.82	2.57	0.67	1.84
112	2.08	0.79	2.02	2.16	1.82
113	2.09	0.69	1.70	3.48	1.80
114	2.04	0.76	0.86	6.33	1.77
115	1.87	1.33	1.60	4.98	1.82
116	1.64	2.36	1.87	3.62	1.86
117	1.45	2.51	2.85	1.80	1.83
118	1.26	2.32	3.44	0.33	1.69
119	1.15	1.57	5.11	-2.13	1.59
120	1.22	1.10	4.69	-1.41	1.51
121	1.56	-0.16	4.21	0.14	1.47
122	2.02	-1.92	3.76	1.98	1.42
123	2.13	-2.76	3.77	3.30	1.37
124	1.83	-1.87	2.44	6.13	1.28
125	1.24	-0.46	1.48	6.61	1.08
126	0.30	1.61	0.39	7.72	0.78

Avg	1.72	1.23	2.92	0.67	1.71
Max	4.05	5.34	7.04	9.48	3.07
Min	-0.70	-2.76	-1.12	-6.99	0.40
STD EV	1.1088	1.6193	1.9267	3.2105	0.73