

# THE INCLINATION OF COASTLINE CHANGES AND ITS IMPLICATION FOR LANDUSE MANAGEMENT OF KARAWANG DISTRICT, WEST JAWA PROVINCE

By:

Ediar Usman <sup>1)</sup>

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## ABSTRACT

*Result of observation at 11 locations and the coastline analysis at year map 1990 published by Bakosurtanal and year map 2005 published by Bappeda of Karawang District shows that the existence of changes of the coastline is caused by abrasion and accretion process. The coastal abrasions are occurred in Muarabaru, South Pusakajaya, Cemarajaya and Tanjungpakis areas. The coastal accretions are occurred in Ciparage - Sukajaya, Mekarpothaci, Cemarajaya - South Pusakajaya, East and West Tanjungpakis areas.*

*During the periods of 15 years the abrasions are occurred with the width of 813,171 ha (8,13171 km<sup>2</sup>) and the coastal long of 30,637 km, and accretions with the width of 1346,22 ha (13,4622 km<sup>2</sup>) and the coastal long of 43,313 km. Every year the width of abrasion is about 54,21 ha or about 0,5421 km<sup>2</sup>/year and the width of accretion is about 89,748 ha/year or 0,8975 km<sup>2</sup>/year. The growth of coastal area about 89,748 ha/year or 0,8975 km<sup>2</sup>/year. If the coastal management is conducted at the abrasion coasts, the coastal damage can be decreased, and the coastal growth for the productive landuse can be increased.*

**Keywords:** coastline changes, abrasion, accretion, landuse development.

## SARI

*Hasil pengamatan pada 11 lokasi dan analisis garis pantai pada peta tahun 1990 yang dipublikasikan oleh Bakosurtanal dan peta tahun 2005 yang dipublikasikan oleh Bappeda Kabupaten Karawang menunjukkan adanya perubahan garis pantai yang disebabkan oleh proses abrasi dan akresi. Pantai abrasi terjadi di daerah Muarabaru, Pusakajaya Selatan, Cemarajaya, Sedari dan Tanjungpakis. Pantai akresi terjadi di daerah Ciparage - Sukajaya, Mekarpothaci, Cemarajaya - Pusakajaya Selatan dan Tanjungpakis Timur & Barat*

*Selama kurun 15 tahun telah terjadi abrasi seluas 813,171 ha (8,13171 km<sup>2</sup>) dengan panjang pantai 30,637 km, dan akresi seluas 1346,22 ha (13,4622 km<sup>2</sup>) dengan panjang pantai 43,313 km. Setiap tahun terjadi abrasi seluas 54,21 ha atau sekitar 0,5421 km<sup>2</sup>/tahun dan akresi seluas*

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1. Marine Geological Institute of Indonesia, Jl. Dr. Junjuran 236. Bandung 40174.  
Email: ediar.usman@gmail.com

89,748 ha/tahun atau sekitar 0,8975 km<sup>2</sup>/tahun. Pertumbuhan kawasan pantai masih lebih besar, yaitu sekitar 89,748 ha/tahun atau sekitar 0,8975 km<sup>2</sup>/tahun. Bila pengelolaan dilakukan pada pantai-pantai abrasi, maka kerusakan pantai dapat dikurangi dan pertumbuhan pantai untuk lahan produktif masih dapat ditingkatkan.

**Kata kunci:** perubahan garis pantai, abrasi, akresi, pengembangan tataguna lahan.

## INTRODUCTION

### Background

The Karawang District is a productive area in the field of agriculture and land & sea fisheries. But some problems with coastline changes such as abrasion (coastal erosion) causing the coastline back step to land (accretion) and sedimentation resulting of coast go forward up at sea has generated some problems. The abrasion has generated the damage and erosion at agriculture farm and fishery land (fishpond). The accretion can increase the productive landuse, but in the other area can generate the problem of sedimentation at the port area, so it will complicate the fishing boats to enter port area especially at the time of low sea level.

The abrasion process is caused by loss of mangrove forest as a protection system at the coast of the survey location. While the accretion process can be due to the sediment supply into nearshore as an impact of the coastal abrasion from its surroundings and erosion from upriver area. The result of accretion growing toward nearshore, may generate many problems in the port pools.

Hopefully this study will be able to give input on coastal management of the coast of Karawang District, so that it can give benefit for all society in the coastal area.

### Condition of the Coastal Geology of Karawang District.

The geology of Karawang District has been formed for a long time as long as the geological history and event started from pre Tertiary until now. The process is distinguished by the sediment progradation forming the wide area as a coastal shelf. Karawang District is as the part of the north coastal system of West Java forming the wide and thickness of the sediment layer. Regionally, nearshore of Karawang District is as an area of the sediment capture. The biggest sediment supply is derived from upland causing subsidence process on the sea floor as an impact of expanding of the normal fault with west – east direction since Tertiary as a consequence of tectonic system at West Java. This process has given the implication into its wide and thickness of the sediment (Bemmelen, 1949).

The coastal area is formed by both interaction between land (geology) and sea (oceanography). Besides, Karawang District is passed through by two great rivers, they are S. Citarum in in the west and S. Cilamaya in the east and also the other smaller rivers namely S. Cidawarak and S. Cibulanbulan. The rivers are come from mountains area in Bogor High, the southern part of the survey location. The Rivers, besides functioning as a source of rice field irrigation it also represents as a sediment transport from upland.

The coastal area (including sub-district coastal area) in Karawang District is a wetland area. This area is utilized by local

resident for agriculture and fisheries areas. Geologically, the lithology in the coastal area of Karawang District is formed by alluvial materials plain which consist of soil, sand and peat. At the top layer of material is black chromatic, peat and downwards the grain is coarse and generally as sand sediment. This sand deposits can be found at the resident wells till 2 km from coastline with shallow ground water face, salty and it is found between 1 - 2 meters from surface.

The pattern of coastline changes, which is oftently the change, require to continue to be studied in order not to have the negative impact to the regional aspect and give benefit to the activity of coastal area society.

#### **Condition of Regional Climatology.**

The condition of regional climatology will effect on the current and wave pattern. Between January - April, the wind is come from South China Sea and Indonesian Ocean with the speed between 10 - 15 knots, and meet in part of west Java Sea with southeast direction to pass through the north of the Java coast with the wave of 2 meters high (Wyrcki, 1961). In May till August, the wind is entirely come from Indonesian Ocean with the southwest to northeast direction with the speed between 10 - 15 knots and the wave of more than 2 meters high. Between September - December, the movement direction of wind is difficult to estimate.

Based on the field study on the coast of the survey location, the western part of the coast is generally marked by the spit river to the west direction, while the eastern part of the coast is generally marked by the spit river to the east direction. This matter shown on the coast of survey location is influenced by winds

from north, northwest, east and northeast directions.

#### **Survey Location**

The survey location is including the coastal area (coastline) and the nearshore of territorial waters of Karawang District within coordinates 107°4'30" - 107°40' E and 05°55' - 6°15' N (Figure 1).

Physiographically, the survey area is including the coastal part of North Java, and geographically the research area belongs to Karawang District, West Java Province.

#### **SURVEY METHODS**

The areas of abrasion and accretion are obtained from the observation result in 11 locations of coastlines and overlay data from two maps. The coastline maps published by Bakosurtanal on year 1990 and Bappeda of Karawang District on year 2005.

Both maps are overlaid by computer system using the software of MapInfo Program. From the overlay process the position and wide of abrasion and accretion areas are obtained and then it is correlated with the field study data.

Another method is the analysis of wind data and flux energy in each observed location. The target is to know the relation between the abrasion and accretion process with wind and wave parameters, so that theoretically it will be obtained by the changes of the coastline. The method is expected to be able to give understanding about the physical condition of coastal area, especially the coastal changes in the survey location. Besides, these methods will be obtained by utilizing picture to support the integrated coastal zone management and sustainable development.

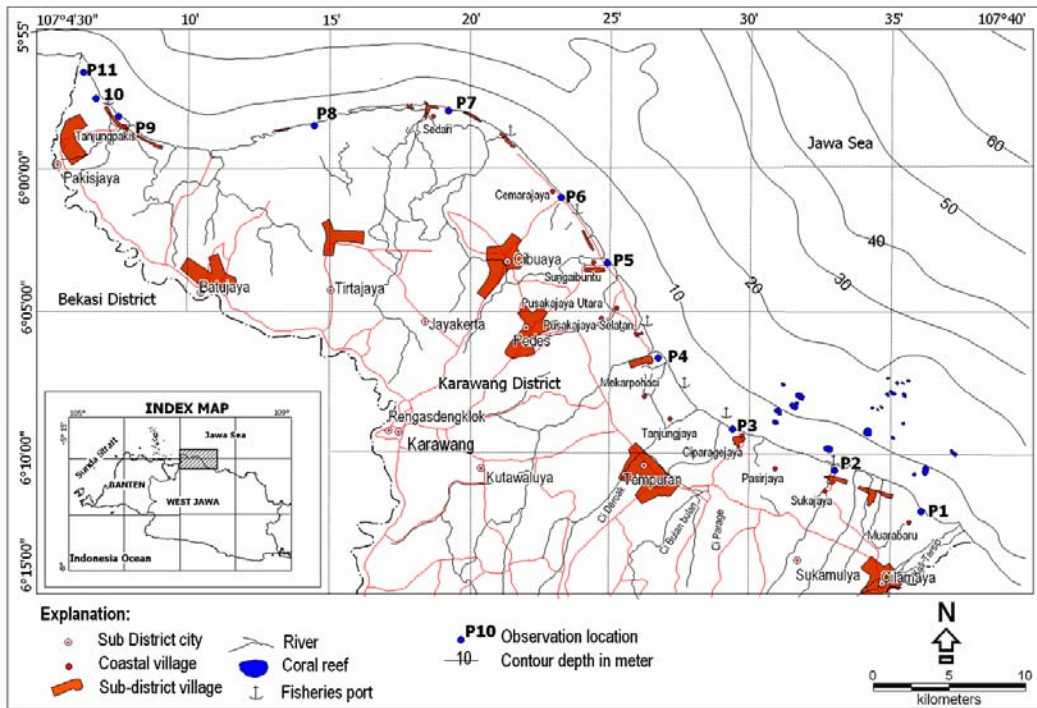


Figure 1. Location of study and identification for coastal process at Karawang District, West Java Province.

## RESULTS

### Wave Flux Energy

The survey location is an open sea, with the coastline horizon look out directly to the Java Sea. On that view point, the wave energy going toward the coast have the maximum effect to the coastal dynamics. The wave energy can cause the abrasion and accretion processes, however, it has also the function to improve the component of the longshore current which can cause the sedimentation in certain area.

The difference of wave parameter from prediction result of each observer location will cause the level difference of wave energy stream on each location. The interpretation result of calculation of wave

energy stream (flux energy) plotted as the evaluation of each observer location will give the indication of longshore current direction on the coastline and coastal process. The coastline shape in the survey area can be divided into two types, they are: the west coast of survey area is relative facing toward the north and the east coast is relative facing to ward northeast. At the west coast, the dominant effect of wind direction to coastal changes is north, east and northeast (NE) directions. While, in the east, they are northwest (NW), north, east and northeast directions.

The result of calculation of annual wave flux energy for the survey location can yield the description about the wave level of energy fluctuation as effected by

the coastal dynamics process forming the abrasion or accretion process that occurred in the survey location, and it is also as the component of longshore current (Figure 2).

In the eastern part of the survey location at Sukajaya, the flux energy is  $-12 \text{ Nm/sec/m}$  with the process that generally occurred is sedimentation, except in the west side of Pasirjaya, while at Ciparage the flux energy is  $19,4 \text{ Nm/sec/m}$ . This place is a stable area shown by the curve mainstream which level off. At Cibuaya (S. Buntu) the flux energy is  $42,9 \text{ Nm/sec/m}$  shows that the area has undergone a sedimentation process. The result of visual observation for this area around estuary of Buntu River shows that very high sedimentation had been

occurred, so that it bothers the fishing boat to exit and entry.

Special for the area of river estuary, the sedimentation process is generally influenced by the existence of the current systems go out to the sea and river current itself. The condition of sedimentation process at each river estuary shows that they are different from one another. This is because of these differences in transportation systems, strength of river current and also by the amount of sediments which are transported by the rivers. The condition of coastal morphology in the survey location is a low slope that occurred when the maximal condition of high sea level of tide current, sea water will pass through into the river estuary, so that the speed of river current will

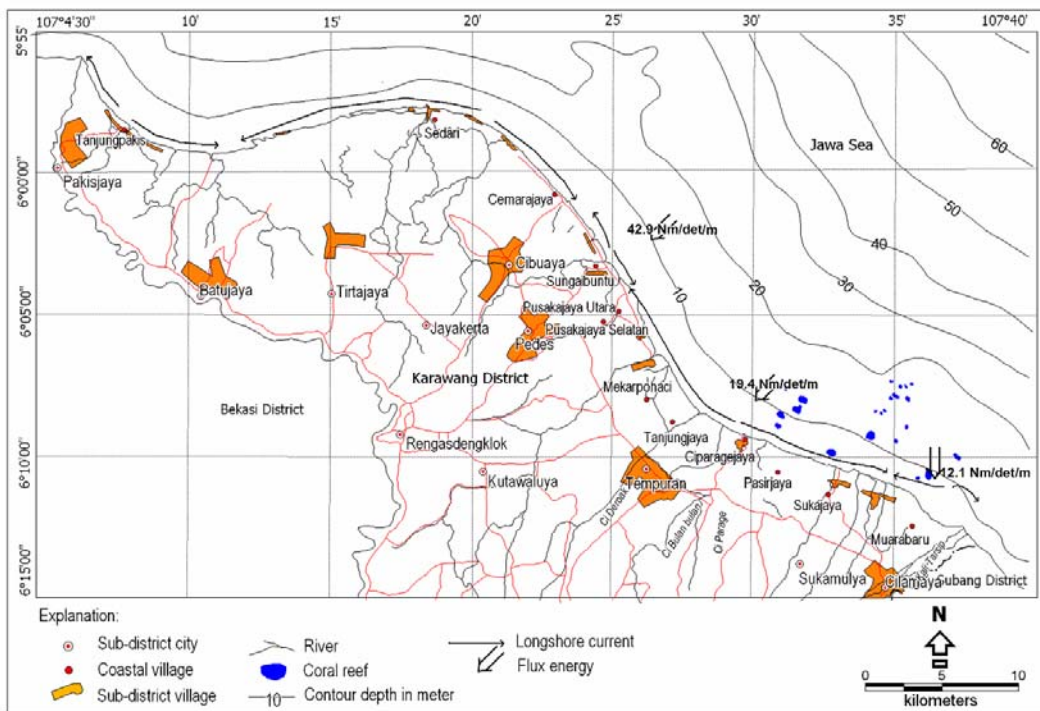


Figure 2. Inclination of the coastline changes based on flux energy analysis of Karawang District (Mustafa and Yuningsih, 2004).

decrease and the transportation of sediment going into the offshore become limited. This process cause the occumulation of sediment in the estuary.

### Coastline Changes

Results of the study at 11 observation locations show that the existence of indication of coastline changes are in the form of abrasions and accretions. This indication can be obtained from the field study and from both map of coastline conducted by various governmental institutions. To obtain about wide and long of coast from abrasion and accretion process, the result of field observation is then correlated with the analysis of coastline map on 1990 published by Bakosurtanal and coastline map on 2005 published by Bappeda of Karawang District. Both maps show that the existence of difference in the coastline changes caused by abrasion and accretion processes. From that result, it can be calculated the average speed of abrasion and accretion processes during range of 1990 - 2005 or around 15 years. The calculation can also predict the tendency of coastline changes for the future.

#### 1. Coastal Abrasion

The coastal abrasion area in the survey location is generally occurred on the coast without protection like breaker zone

and mangrove. The coastal abrasion is generally have formed a long coastline and regionally forms the beach embayment. At Muarabaru and Tanjungpakis, some trees as protection of the coast have been decreased and the wave is slowly eroding the coastline to upland direction. The effect of the wave eroded on the coast, the sea water colour is turn into yellow because it consists of high yellow mud in sea water (Photo 1).

Results of study at 6 observation locations and calculation of wide and long of the coastline changes on two maps show that these location are the abrasion areas. The coastal abrasion is occurred in Muarabaru (Cilamaya Wetan Sub-district), South Pusakajaya (Cibuaya Sub-district), Cemarajaya (Cibuaya Sub-district) and Tanjungpakis (Pakisjaya Sub-district). The total wide of abrasion reaches 813,171 ha (8,13171 km<sup>2</sup>) and 30,637 km long, or around 41,43% from total coastline of the survey location in this time (Table 1).



Photo 1. Abrasion process at Tanjungpakis (P10).

Table 1. Result of coastline wide and long as an impact of abrasion process at Karawang District.

No	Points of Observation	Coastal Process	Location	Wide (Ha)	Coast Long (Km)
1	P1	Abrasion	Muara Baru	569,6	5,621
2	P4		Pusaka Jaya Selatan	8,835	1,111
3	P6	Abrasion	Utara Cemara Jaya	8,659	2,869
4	P7	Abrasion	Sedari Timur	103,4	5,047
5	P8	Abrasion	Sedari Barat	117,9	14,966
6	P10	Abrasion	Tanjung Pakis	4,777	1,023
Total				813,171	30,637

The biggest coast of abrasion process is in Muarabaruu coast with the wide of 1,9 km and 5,621 km long. Other coastal abrasion are in West and East Sedari with the wide of 221,3 ha and 20,013 km long. While in other coasts they are ranging from 300 - 500 meters.

## 2. Coastal Accretion

The accretion area at the survey location, is generally occurred at the coast having protector like mangrove and breaker zone (coral reef). The coastal accretion, is generally have formed by coastal sandbank. This condition concerning the coastal accretion can be seen in Sukajaya coast as the biggest wide of accretion (Photo 2).

At Sukajaya area, naturally, the mangrove forest and root of mangroves are growing as traps of mud sediment, so that they form a new coastal plain. The result of the accretion processes is utilized

for the farm of coastal area fishery, like rice field and fishpond by the resident.

The result of observer at 11 locations and calculation on two maps are wide and long coasts of accretions. The coastal of accretion is occurred in Ciparage (Tempuran Sub-district) - Sukajaya (Cilamaya Kulon Sub-district), Mekarphaci (Pedes Sub-district), Cemarajaya - South Pusakajaya (Cibuaya Sub-district) and East & West Tanjungpakis (Pakisjaya Sub-district). Amount of all coastal wide of accretion



Photo 2. The accretion process at Sukajaya (P2).

Table 2. The result of coastline wide and long as an impact of the accretion process at Karawang District

No	Point for Identification	Coastal Process	Location	Wide (Ha)	Coast Long (Km)
1.	P2, P3	Accretion	Ciparage-Sukajaya	777	16,10
2.	P4	Accretion	Mekarpohaci	136,1	5,31
3.	P5	Accretion	Cemara Jaya-Pusakajaya Selatan	314,8	12,12
4.	P9	Accretion	Tanjung Pakis Timur	26,69	7,007
5.	P11	Accretion	Tanjung Pakis Barat	91,72	2,776
Total				1346,22	43,313

reaches 1346,22 ha (13,4622 km<sup>2</sup>) and 43,313 km long, or around 58,57% long from total of coastline of Karawang District at this time (Table 2).

The coastal accretion process at Ciparage - Sukajaya is about 777 ha wide and 16,10 km long, and in Cemarajaya - South Pusakajaya is about 314,8 ha wide and 12,12 km long, while other coastal accretions are smaller in wide and length.

The accretion in the field shows the increasing of sediment supply from upland because the increasing of erosion in upland. This condition is seen from sea water colour at estuary area and nearshore with high mud content (Photo 3).

Although it is difficult to explain since when in fact the changes of the coastline underwent its rise, but by using two maps, at least it can describe the coastal changes in Karawang District into two different times. The changes are expected to be able for the prediction in the future.

Generally, the coastal accretion lies in the middle coastline of the survey location from North Ciparage till Muarabaru, and the coastal abrasion only occurred in a small part. Another accretion is located in the northern part of Tanjungpakis (Figure 3)

The coastal accretion in this area is influenced by wind and wave pattern as a result of longshore current movement with direction toward the east and west. Dominant wind in this area is influenced



Photo 3. Supply sediment by Citarum River as a sources of sedimentation at the coastal area. Photo from Airplane. Location: West Tanjungpakis (P11).



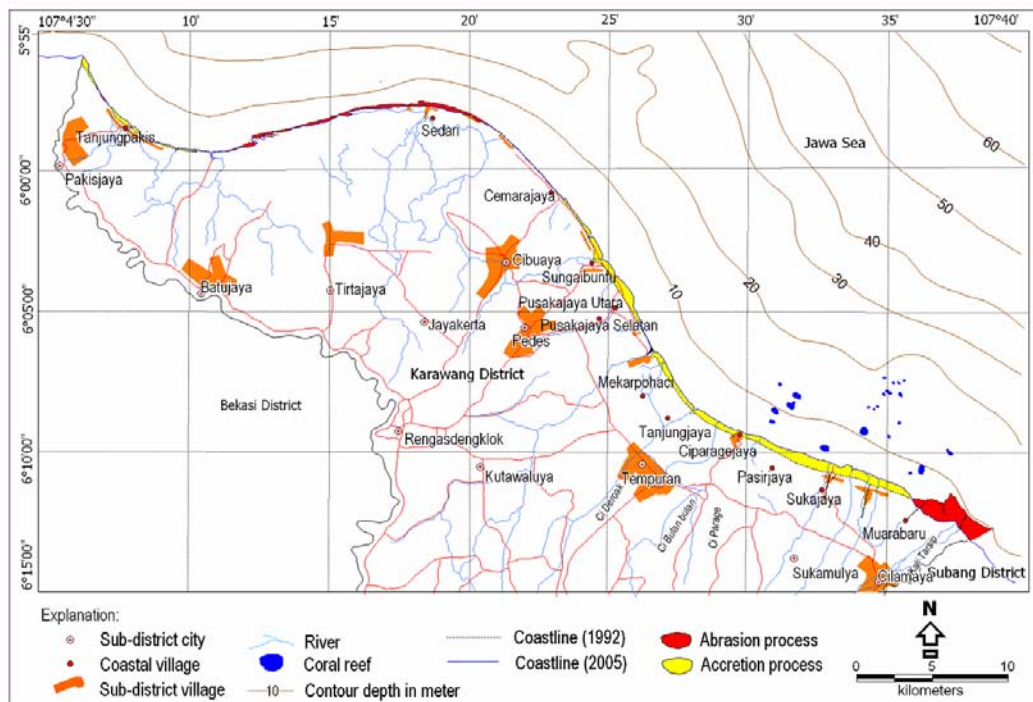


Figure 3. The coastline changes at Karawang District between 1990 - 2005 (Usman et.al., 2005).

by wind direction from northeast (NE) and north (Source: BMG, 1992).

In the western part of Cemarajaya area till Tanjungpakis, the movement of longshore current is towards the west direction. Generally, the currents bring some result of sediment supply from upland through the rivers causing the coastal abrasion from the east to the west direction and it is deposited around Tanjungpakis area. While in the eastern part of the survey location, starting from Cemarajaya area till Sukajaya, the movement of longshore current is eastwards following the coastline pattern. Generally, the currents also bring the sediment product from upland through the rivers and they are resulting abrasion to east direction and they are deposited

around Cemarajaya till Sukajaya coast. The sediment supply can cause the effect of abrasion in Muarabaru area. The sediments materials are deposited in the western part of the survey location.

The coastline changes occurred in the survey location show also the high sediment supply in the sea floor. This matter is caused by sediment from upland and coast as an effect of abrasion forming the slump structure on the sea floor. This condition can be seen from bathymetry pattern which is following the coastline pattern, as a widely filling the sediment on the sea floor. In offshore of Cemarajaya it forms a dome morphology about 10 - 20 meters depth, and offshore area of Cilamaya, the sediment is closed and

destroyed the body of coral reefs (Usman et.al, 2005).

## DISCUSSION

### Speed of Abrasion and Accretion Process

Since 1990 to 2005 or around 15 years, the coast has undergone the abrasion process reaching 813,171 ha wide (8,13171 km<sup>2</sup>) and 30,637 km long, or around 41,43% from total long of the coastline of the survey location at this time. Speed of abrasion in the survey location per year reaches approximately 54,21 ha/year or 0,5421 km<sup>2</sup>/year. While coastal accretion reaches 346,22 ha wide (13,4622 km<sup>2</sup>) and 43,313 km long, or around 58,57% from total long of Karawang District coastline in this time. Every year, the accretion has even happened for approximately 89,748 ha/year wide or around 0,8975 km<sup>2</sup>/year.

From the speed of abrasion and accretion processes, the coastal growth toward the sea is bigger compared to coastal erosion with the difference of 533,049 ha wide during 15 years. The growth of land toward offshore is approximately 35,54 ha/year.

### Coastal Management

The management of the coastal damage in the future like abrasion at the area of agriculture and fisheries, and also accretion at port pool requires to manage with the sustainable development. This activity needed to manage the coastal damage is to identify the cause of the coastal damage. From this survey, it can be identified the possibility of the coastal protection like the development of mangrove forest, breaker zone and reefs conservation. If the damage can not be stopped, the coastal damage will be harder at land productive like agriculture

and fisheries farms. This condition will influence the economic growth of the local community at the coast of Karawang District.

On that account, it is required to rehabilitate the mangrove forest and strengthen the coastal defense (sea wall) in the productive land and port areas. Besides, the activity of the fisheries land in the coastline must be stopped because it will be destroyed by the abrasion. The other effort is to manage the erosion in upstream by doing the rehabilitation of forest, so that the erosion can be reduced in the future (Dahuri et.al, 1996).

## CONCLUSION

Based on the result of field observation and comparison of coastline on 1990 and 2005 or almost 15 years, the coastal abrasion reaches 813,171 ha wide (8,13171 km<sup>2</sup>) and 30,637 km long, or around 41,43% from the total coastline of the survey location. Coastal accretion reaches 346,22 ha wide (13,4622 km<sup>2</sup>) and 43,313 km long or around 58,57% from the total coastline of Karawang District. The speed of abrasion is approximately 54,21 ha/year or around 0,5421 km<sup>2</sup>/year, and the speed of accretion reaches 89,748 ha/year or around 0,8975 km<sup>2</sup>/year.

From the speed of abrasion and accretion processes, the coastal growth towards the sea direction is still bigger compared to the coastal abrasion with the difference of 533,049 ha wide during period of 15 years. Every years the coastal growth is about 35,54 ha wide. The amount of the coastal growth can increase if the abrasion processes at the coast along 30,637 km or around 41,43% from total coastline of the survey location can be managed better.

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