MORPHODYNAMIC OF LAGOON SEGARA ANAKAN CILACAP CENTRAL JAVA

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Abstract

Morphology in Segara Anakan Lagoon has been actively changing for years which including all of morphology unit. Data in 1900s show that the width of lagoon changed significantly from 6,868 hectares to become 1,800 hectares reported in 1998. In accordance with the width and the depth change caused by high rate sediment supply, the new mainland had been formed to be additional one to coastline and the bars morphology unit was followed by expansion of mangrove pioneer. Analysis was carried out using aerial photograph and Geographical Information System (GIS) application. Result of the analysis to show tidal flat morphology unit was one possessing most significant change including its pattern, width and direction.

Abstrak

Dinamika morfologi di Laguna Segara Anakan telah berlangsung sejak lama yang meliputi perubahan diseluruh unit morfologi yang ada. Pada tahun 1900 luas perairan laguna meliputi 6.898 hektar dan terus berkurang hingga tinggal 1800 hektar pada tahun 1998. Sehubungan dengan terjadinya perubahan luasan dan kedalaman laguna yang dikarenakan oleh tingginya angka suplai sedimen yang masuk dan mengendap di laguna selain mengakibatkan majunya garis pantai juga membentuk unit morfologi bars yang baru yang di kokohkan keberadaannya dengan tumbuhnya mangrove pioneer. Dalam analisis, digunakan aplikasi Sistem Informasi Geografis (SIG) dan foto udara. Hasil menunjukan bahwa unit morfologi tidal flat merupakan unit morfologi yang paling signifikan perubahan pola, luasan dan arahnya.

1. INTRODUCTION

Segara Anakan (Jawa Language) is meant as son of the sea, it is an estuary like lagoon in the south of Jawa Island which consist of 5,000 hectares of productive mangrove forest and about 1,500 hectares watery area (Based on the data in 1997). The lagoon is also know as the biggest one in Jawa Island (Ongkosongo, 1985) with its mangrove forest recognized as one of big mangrove areas with its north–east thickness reaches several kilometer away. The south part of the lagoon is hampered from the influence of Indian Ocean by the existing of Nusakambangan Island which relatively extend to 30,000 hectares in west–east.

Segara Anakan Lagoon has been actively changing for years. The active change also consist of alteration on landscape. Data in 1900s show that the width and the depth of the lagoon changed significantly from 6,868 hectares with its average 2.7 meter depth (Ongkosongo, 1985) to become 1,800 hectares with its only several meter depth (less than 0.5 meter) reported in 1998 (Hindaryoen, 2001). In accordance with the width and the depth change, the new mainland had been formed to be additional one to shore line mainly in the east coast and the formation of the new islands was followed by expansion of mangrove pioneer. Until 1984s the island formed in the lagoon had been possessing its 1,289 hectares width (Ongkosongo, 1985).

The landscape change happening at Segara Anakan Lagoon was dominantly caused by the high rate river sediment. Ci Tandui River is the biggest sediment supply with the amount of 3.8 million m^3 /years including from Segara Anakan Catchments Area and Nusawuluh Flood Way each 1.6 million m^3/years and 0.62 million m^3/years (Napitupulu and Ramu, 1982).

In view real phenomena was happened, papers below tried to analysis morphodynamic process in Segara Anakan Lagoon with pressure in the spatial changes

II. METHODS

The large part study area was administratively included in 22 villages in 3 sub districts in regency of

Cilacap, Central Jawa. A large part of its lagoon includes 3 main village know by local inhabitants as "Kampung Laut" and also includes Ujung Gagak Village in the north, Panikel Village in the east and Ujung Alang Village in the south and east part of the lagoon which are all part of administrative zone of Sub District Kawunganten.

The area of study, geographically extend 7° 33' 53,97"-7° 43' 54,29" south latitude and 108° 46' 48,72"- 108° 55' 41,52" east longitude.

Maps used in this study as follow :

a) Topography map year 1940 with 1 : 50.000 scale produce by Army Topography Service (DinasTopografi Angkatan Darat) sheet 42/XL I-D, Kalipucang, 42/XL II-B, Pangandaran, 43/XL I-C, Kawoenganten and sheet 43/XL II-A, Noesakambangan
b) Land use thematic map year 1970 with 1 : 50.000 scale, produce by Directorate Land Use (Now National Land Agency (BPN)), sheet 42 BW4, Kaliputjang, 42 BX2, Pangandaran, 43 BW3, Kawunganten and sheet 43 BX1, Nusakambangan
c) Coast line thematic map year 1970 and 1 : 50.000 scale
d) Indonesia Topography Digital map (RBI Digital), year 1999 with 1 : 25.000 scale, produce by National Mapping and Survey Coordinating Agency (BAKOSURTANAL), sheet 1308-241. Kaliputcang-1308-242, 1308-243, Gandungmangu and sheet 1308-244, Kawunganten
e) The aerial photograph used was with scale 1 : 20.000, year 1999 and was then enlarged to 1 : 10.000.

Identification of lagoon morphodynamic was carried out with overlay technique even the lagoon morphodynamic map was made by dividing observing area into 6 (six) classification based on the difference of water muddiness rate and land use. The above differences could be interpreted from gray scale in aerial photograph and the result of field observation. The classification are as follow:

1. Region with low muddiness scale region with ordinary muddiness scale
2. Region with high muddiness scale
3. Region of new bars (without/little mangrove vegetation)
4. Region of bar with mangrove vegetation
5. Region of bar with fishpond and/or rice field.

The analysis morphodinamic, could be done Geographical Information System (GIS) by calculating its width each class region classification. The width of each classification its developing course and width could be furthermore predicted.

III. REVIEWING AND RESULT

3.1. Physical Setting Of Segara Anakan

3.1.1. Geomorphology And Geology

Segara Anakan is geomorphologically located at the end part of Ci Tandui Basin and know as a part of Bandung Zone at intermountain depression lane in longitudinal form lengthening formation is alluvium sediment which can be found along river stream from Tasikmalaya in Westren Java to South part of coastal area in Central Java (Nelson, et, al., 1992). Van Bemmelen (1949) mentioned that this area is low landing coast located in the middle of depression zone and also know as Ci Tandui depression continuously. Eastern low landing coast is beach ridges with the height of 2–4 meters sea level and lengthening to South and North around Town of Cilacap to the East around Karangbolong (Ongkosongo,1985). Western coast of the low land including Segara Anakan Lagoon is low landing area surrounded by hills with relatively horizontal relief and slope rate from 0% to 2% (Nelson, et, al., 1992).

Based on its morphogenesis, Segara Anakan Lagoon and it surrounding is divided into 4 morphogenesis unit including marine origine form structural origin form, fluvial origin form and karts origin form (Anon, 1997). Marine origin form is one with the widest extending, including in the east, north, west and south side of lagoon.The spreading out of marine origin form reaches 10 kilometers if measured from coast line to the north.

Raharjo (1982) divided geological region of Segara Anakan–Cilacap in east and west part. The east, geology is dominated by coastal low land possessing horizontal topography formed by beach sand intercalation with iron sand. West geological area is much influenced by process happening at up land area where teresterial agent is very dominant. This is shown by relatively very smooth coast line and by intensive sediment process. Datun (1981) and Ongkosongo (1985) supposed that he oldest formation in Segara Anakan was miosen limestone

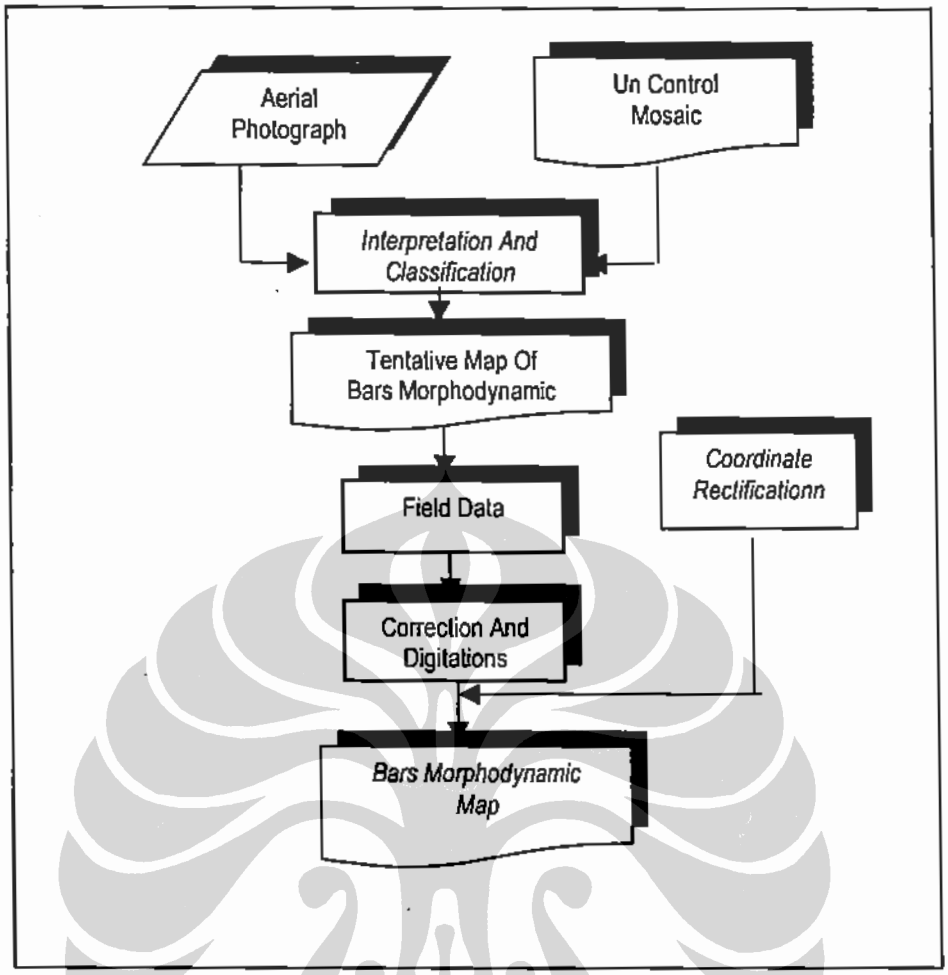


Figure 1. Production Process of Bars Morphodynamic Map

formation in the form of ridge of rock limestone and clastical limestone where in several parts, napal was sometimes found out and the youngest geology of Segara Anakan is dominated by unconsolidated clay and sand size sediment, so that its formation is very soft and spreading out. As the result of drilling data by Ongkosongo (1985), the lagoon edge and the new island are ordinary formed from sediment fraction in small size one (clay) with rougher sediment fraction located underneath. Klaces Village at lagoon edge in the North Nusakambangan Island, shows that clay size fraction found there, its thickness reaches more less 3 meter and in the island part, the drilling worked near and directly facing with the Ci Tandui River outlet, shows that sand size fraction with thickness reaches 4 meters and become thinner to the west.

3.1.2. Climate

Area of Segara Anakan along with other regions in Jawa Island has 2 season, rainy season happening from November to April with its average rainfall was about 180–400 mm and dry season happening from July to November with its monthly average rainfall is about 100–180 mm. Yearly average rainfall in this region was 2900 mm with minimum in August (87 mm) and maximum happened in November (378 mm) (White, et, al., 1989). Uktoselya (1984) did research analysis wind direction and velocity in Cilacap and its surrounding by using tens years data. Conclusion made through this research was the maximum windy velocity happening in July with south-east direction.

3.1.3. Hydrology

Segara Anakan is the biggest sub catchments in Ci Tandui Catchments Area with its width reaches 103,600 hectares. The main river streaming in this region and ending in Segara Anakan Lagoon, consisted of the Ci Tandui with its length is more less 200 km in west, Ci Bereum and Ci Konde in the north and Kembang Kuning, Dangal and Ujung Alang in the west (Anon, 1993). Ludwig (1985) mentioned that there is 20.5 million m^3/days of

average stream reaching the lagoon from the river such as Ci Tandui and Ci Bereum. Average amount of water flowing to the lagoon is depend on regional climate. In dry season, the water stream to lagoon reached 14.9 million m^3/ day and increased to 26.12 million m^3/day in rainy season.

Table 1. Hydrology Of River Around Segara Anakan Lagoon (Ludwig, 1985)

Basin And River	Basin Width (km^2)	Average Of Water Flow (m^3/day)			Estimation of Mud Taken To Lagoon (t/year)
		Dry Season	Rainy Season	Year Average	
Cl Tandul	3.500				
Cl Tandul		14.770.000	24.450.000	19.610.000	3.039.000
Segara Anakan	960				
Ci Bereum		50	170000	85.025	9.000
Cl Konde		80	1500000	750.040	2.194.000
Total	**4.460**	**14.900.000**	**26.120.000**	**20.445.065**	**5.242.000**

Groundwater in Segara Anakan was relatively unprovided well, neither its quality nor quantity. Water was only sufficient in Nusakambangan Island in the limestone formation. This condition was possible referring limestone caused by dissolving on the limestone which was possible infiltrating of water into the stone. The limestone were than located and hidden in caves or move and formed underground rivers.

In the new formed island, groundwater area unable to be found because generally the all accumulated fraction not consolidated yet. Water around the lagoon was found in little amount with its bad quality. This bad water quality was indicated by its salty taste and its muddy color.

3.1.4. Tide And Current

Tides in Segara Anakan had been research by Datun (1981), Sutomo (1982), Ecology Team IPB (1984), White (1989) and Wibowo (1997). Datun (1981), mentioned that in estuary area, the current could be in influence by several others one except if there barrier with its narrow parting its tip, then, the most influencing one was the rise and fall condition of the tide. The tide in Segara Anakan was semidiurnal type (Sutomo, 1982). Semidiurnal meant in the one day there are 2 times rise and 2 times fall periode. The interval between rise and fall was around 100 to 148 cm, 40–90 cm or 98–152 cm (Ecology Team IPB, 1984 ; White, 1989 ; Wibowo, 1997) with its time interval was around 5 hours or 1-2 hour relatively later than the period happening in the Indian Ocean in the south part (Cilacap Tide Station).

Nusakambangan Island located in the south lagoon causing the sea current which came from Indian Ocean in the South, wasn't directly referring all to the lagoon. The current coming in and out to Indian Ocean was dominated by the rise and fall through 2 inlets in the East of The Kembang Kuning in the West through the Selok Jero Strait. The current which coming through the Selok Jero Strait in the West of Nusambangan, when reaching into the lagoon relatively still possessed bigger energy and velocity on account of its short distance to open sea, meanwhile the current coming through The Kembang Kuning as the inlet in the east relatively lessening energy and velocity to the west way referring to the long way of the inlet distance to the lagoon and a large part of crossing with big river such as Donan and Sapuregel River.

The current in the Segara Anakan had been researched by Datun (1981), Hamidjojo (1982), Uktolseya (1984) and Wibowo (1997).

The main point of the research, was that in rising tide condition current from Indian Ocean moved through in the inlet of Selok Jero Strait with its lessening power to the north and east until northeast and met with current which coming through the east inlet in the around of Motean Village. It was said that the current coming through the inlet Selok Jero Strait had its velocity of around 0.9–1.2 meter/sec. This figures was bigger than the measurement done by Wibowo (1997) who mentioned

that the current velocity in the lagoon was around 12–25 cm/sec.

3.2. Study Result

3.2.1. Morphology Of Segara Anakan

The morphology structure of Lagoon Segara Anakan like lagoon generally structure consisted of several morphological unit such as inlet morphology unit, bars morphology unit, barrier island morphology unit and morphological unit of tidal flat (Davis, Jr, 1991 ; Gross, M.G, 1995) still had change. Ongkosongo (1985) mentioned that the physical structure change had been at least begun for 17,000 years by sedimental process that happened furthermore after the last lifting of plioplistosen formation (Datun, 1981)

The previous research (Schaafsma, 1924 and Hadisumarno, 1964, 1979) showed that there was the difference of morphology change which was significant enough between the east and west part of the lagoon. The east part changed faster than the west part which was indicated by the rapid of coastal growth. The changing difference he was very close to the difference of current energy caused by the difference of lagoon position to the inlet and main river directing to the lagoon. Arifin and Sarmili (2000) mentioned that east current energy was weaker than the one in the west which its current energy was the direct calculation of tidal current energy and the energy of the main river (Ci Tandui, Ci Bereum and Ci Konde). The large amount of small rivers in the east part which by Arifin and Sarmili reported as the current energy absorption in the east part giving contribution to current energy decreasing so that the coming sediment to the lagoon would be deposition relatively more in this part.

In the process of morphology change represented from shoreline change, the lagoon also had the depth and width decreasing. In 1900, lagoon Segara Anakan possessed 6,898 hectares width with its bars width was 223 hectares (Abadi, 1984 ; Ongkosongo, 1985) and continually decreased to 1,575 hectares in 1994 (Dewanti and Maulana, 1998). Another was the lagoon depth which continually changed from 2.7 meters average depth in 1900 (Ongkosongo, 1985) to be 0.5–0.6 meters in 1924 (Schaafsma, 1924) and 0.1–0.3 meters in 1964 (Hadisumarno, 1964) until only several centimeter in 1998 (Hindaryoen, 2001). The depth and width change of lagoon Segara Anakan was caused by increasing sedimentation from only 0.5 million m^3/year to 5.65 million m^3/year in 1998 (Anon, 1998).

Map overlay result in 1940, 1970 and 1999 showed that morphology change had happened in all morphology unit in lagoon Segara Anakan. Significant change happened in tidal flat morphology unit especially in the east and north of lagoon (see map no.1).

3.2.2. Inlet Morphology Unit

The inlet at Selok Jero Strait is one of two inlets connecting lagoon Segara Anakan with Indian Ocean in south and another inlet named The Kembang Kuning located in east part. The measure of this morphology unit was more less 6 (six) kilometers in its sinuous form with 1,064 meters width in south part and getting narrower to more less 325 meters in north course. Ongkosongo (1985) mentioned that the sinuous inlet forming was a proof that this inlet, 17,000 years ago was main river channels flowing to open sea from the big lake in its north part which at the time, its se level was 120 meters under the present sea level.

The sounding result by Ongkosongo (1985) around the inlet showed that its inlet maximum depth was around 17.5–20 meters with river bed sediment dominantly consisting of sandy fraction (Arifin and Sarmili, 2000). Since the depth research carried out by Schaafsma (1924) was reported, people than knew that the inlet's depth no much changed compare to the lagoon average depth. The inlet depth that didn't change much and at sandy fraction as dominant sediment of river bad showed that the current energy in inlet was very big which by Uktolseya (1984), was mentioned to have velocity of around 0.9– 1.2 meters/second.

By looking the position of shoreline from 1940 to 1999, spatially inlet morphology unit showed significant change in east and west position caused by at least 3 (three) fundamental matters as follow, (1) caused by inlet position that was relatively near to the outlet of Ci Tandui which becoming the most sediment, (2) its short distance with open sea and (3) its sinuous form.

The near position to Ci Tandui outlet and the sinuous form caused inlet in the western part had sedimentation, until such period, the shoreline grew to

average 278 meters to east with maximum distance is 885 meters, which practically formed new mainland with its more less 110 hectares. Its tidal current measure flew in and out through inlet both settling sediment in one side and also causing abrasion in the other side. The abrasion indicated by moving back its shoreline, could be seen in east part. Inlet morphology unit in the east part moved back to the east with its average reaches 220 meters and its maximum distance reached 308 meters. This part then changed moreless 16 hectares water area.

3.2.3. Bars Morphology Unit

According to Whitten (1999) this unit had been seen since 1924 which by Ongkosongo (1985) was mentioned that its width was more less 346 hectares.

Continued by the increasing of sediment supply to the lagoon, from 1940 to 1970 spatially this unit grew continually. The bars morphology unit, in the west lagoon grew to the north east with its average growth was 867 meters and its maximum distance was 1025 meters, another was the average growth of 449 meters to west with its maximum distance was 500 meters and average growth of 443 meters to north west with maximum distance 588 meters. Both were experience growth from 1940–1970 and the other was also newly formed bars morphology unit, mainly in the southern part of the lagoon next to the North of Nusakambangan Island. The whole width of this morphology unit was 739 hectares in 1970. Its growth was significant enough from only 218 hectares in 1940.

In the period of 1970–1999, the bars morphology unit which have been formed before was continuing experiencing growth. The bars unit in the west of lagoon where in its past period grew to north east, was continuing growing to the same direction, so that, it, in the last period would get together with tidal flat morphology unit located in north part and then continue to west part with its growth reached to the distance was 4,000 meters. The bars unit in the lagoon, both growing to the north east, it also grew to the west average 702 meters with 772 meters maximum distance and to the north west was average 615 meters with a 624 meters maximum distance. The bars morphology unit in south east lagoon continually grew to the north average 1,149 meters with a 1,600 meters maximum distance and to the east average 1,313 meters with a 1,900 meters maximum distance. The whole width area of bars morphology unit was 1,095 hectares in 1999.

Newly formed bars morphology unit continually grew to the South part of Karang Anyar in the North part of Nusakambangan Island for period 1970–1999 or its exact period was after the year of 1978. This fact was taken from land satellite data year 1978 showing water with muddy concentration was at the location where the bars were in fact formed.

3.2.4. Barrier Island Morphology Unit

Barrier Island was lagoon morphology unit theoretically formed from sedimentation result of its sediment with its lengthening from was the same way to shoreline. Nusakambangan Island, which was morphology unit in Lagoon Segara Anakan and arranged by limestone formation in the east part, breccia in south east and new un consolidated sediment in the north This morphology unit, as morphogenesis, its large part was arranged from the structure origin form together with karts and marine origin formation.

Spatially, morphology unit of Barrier Island from 1940 to 1970 continued growing represented by the front moving of the shoreline in The North Nusakambangan to the North East average 432 meters and 789 meters maximum distance and in that period, there was new land with 200 hectare width. From 1970–1999, this morphology unit continued growing to the same direction with average 184 meters and a 224 meters maximum distance. Several bars morphology unit, in Nusakambangan which was previously formed, in the period of 1970–1999 united to morphology unit of barrier island as the effect of shoreline moving in this unit. Morphology unit of this barrier island wholly had 48 hectares width. This figure was smaller than the width formed from the same unit in the previous period.

3.2.5. Tidal Flat Morphology Unit

Based on theoretical criteria, it was said that tidal flat was a flat with low slope surrounding a lagoon, which at high tide would get such the region, this unit, as found in Segara Anakan lagoon was the biggest morphology unit compared to another unit. In study area, tidal flat morphology unit , mainly in

the east, north and west are, their distance reached several kilometers if counted from its present shoreline.

In the period of 1940 – 1970, this morphology unit spatially grew significant enough mainly in the east part of the lagoon averagely 876 meters with 1,160 meters maximum distance to west and in the north part of the lagoon grew to south way averagely 428 meters with a 609 meters maximum distance. This morphology unit found in the north of south east part grew averagely 118 meters and 245 meters maximum distance. This fast growth meant the width addition of tidal flat morphology unit in amount of 815 hectares.

In the next 1970–1999 period, the tidal flat growth became very progressive in the east and mainly in the north part of lagoon. Morphology unit of north tidal flat averagely grew to 3,583 meters and with a 4,000 meters maximum distance. Together with the growth of tidal flat morphology unit in the north, this unit in the east growing to west part and at the end of period 1970–1999, this morphology unit met with tidal flat unit which growing to south west and the bars morphology unit in the west lagoon growing to the north east. The east morphology unit growth was averagely 1,128 meters and 2,780 meters maximum distance to west part. The morphology unit of tidal flat formed at the end of 1970–1999 period was as wide as 1,916 hectares.

In addition to the progressive growth in north, west and east part, period 1970–1999, it was in fact followed by abrasion causing moving back of a shoreline part found in east–south east lagoon. The shoreline moving back process happening in this part could be refer to several matters, (1) the more lessening width of the lagoon mainly in the north part, (2) the lagoon's form changes caused by width lessening, such as river's indentation and (3) the same current power consistently coming to the lagoon. Current power that was usually big and continually became weaker to the north part, at the time the lagoon still possessed large, and at the time the lagoon became narrower in the north part, causing the current coming to the lagoon continually moved to the east part with big enough power and then turned because of new lagoon causing the abrasion in east–south east of the lagoon. Morphology unit of tidal flat, its decreasing caused by abrasion process was 25 hectares.

Table 2. Width Changes Of Morphology Units In Segara Anakan Lagoon

No	MORPHOLOGY UNIT	PERIOD	
		1940–1970	1970–1999
1	Bars	521	356
2	Barrier Island	200	48
3	Tidal Flat	815	1.916

Source : Analysis result

3.2.6. Bars Morphology Unit – A Specific Analysis

Analysis to morphology of the lagoon was more detail carried out by analysis bars morphology unit in its form as small bars located in the South part of Karang Anyar consisting Nusa Karangbraja and Nusa Tirangesik. Based on observation carried out visually with the help of computer, the observing area could be classified in 6 (six) developing stages to the change its morphology. The stage as follow :

1. Water with low muddiness stage
2. Water with ordinary muddiness stage
3. Water with high muddiness stage
4. New bars with or without pioneer mangrove stage
5. Bars with mangrove vegetation stage
6. Bars with fishpond and/or rice field stage

From the total amount of observing area reaching 915 hectares, the 120.4 hectares was the width from 3 classification stages of bars with or without pioneer mangrove to the bars with pond and/or rice field and the remaining 481.7 hectares was water with low muddiness stage to the water with high muddiness stage. Another one was 312.3 hectares as older landing.

With the assumption that the sediment coming to the lagoon always consistent, current system unextremely changes and un intervention of human being so this one means that the stage of morphology period happening in bars morphology unit which was observed is the first, the second and the third periodic stage.

The first periodic stage is the one which the previous water possessing low muddiness that would be changing to be high level muddiness water. The previous water that was the one with high level muddiness would change to become new bars unit which its position would be consistent signed by the natural growing of pioneer mangrove. At this

extending stage, new bars unit would be formed with its 70.66 hectares width or the same width as the previous one possessing high level muddiness.The previous bars unit which in their form were with or without pioneer mangrove would change to become bars unit with mangrove naturally overgrown by mangrove as wide as 48.32 hectares. At the second periodic stage, water with high level muddiness would become 267.25 hectares meanwhile bars unit with or without pioneer mangrove would be larger with its 144.47 hectares width. Bars unit with mangrove would become 70.66 hectares compare to its previous 48.32 hectares width. At the third periodic stage, the previously existing water would all change to become bars unit where there was pioneer mangrove with its 267.25 hectares width and bars unit with mangrove on it would be 144.47 hectares (see map no. 2).

Table 3. The stage of bar morphodynamic unit

Muddiness Level And Morpology Difference	First Stage	First Periodic Stage	Second Periodic Stage	Third Periodic Stage
	(hectares)	(hectares)	(hectares)	(hectares)
Water with low level muddiness	267.25			
Water with ordinary level muddiness	144.47	267.25		
Water with high level Muddiness	70.66	144.47	267.25	
New Bars Unit with or without pioneer Mangrove	48.32	70.66	144.47	267.25
Bars Unit with Mangrove	38.49	48.32	70.66	144.47
Bars Unit with pond/rice field	33.76			
Other mainland	312.35	312.35	312.35	312.35
Total	915.3	915.3	915.3	915.3

Sources : Analysis result

IV. CONCLUSION

1. The water area of Segara Anakan Lagoon, had been experiencing abrasion from 1940 to 1999 followed by the changing of morphology unit. Tidal flat morphology unit was one possessing most significant change including its pattern, width and direction.
2. Bars morphology unit in the Nusa Karangbraja, The Nusa Tiranggesik and their surrounding grew faster to north east–south west. This whole region would supposedly become mainland at he third periodic stage of on going morphology extending stage.
3. The forming of new mainland referring to the addition of coastal line was almost followed by land use change happening on it. New formed mainland was generally an naturally was overgrown by pioneer mangrove then to be older mangrove and its place was furthermore changed by rice field land use.

V. REFERENCES

Anon (1997): Penyusunan data spasial tematik Kawasan Segara Anakan Cilacap, Jateng, Ditjen BANGDA dan BAKOSURTANAL, Jakarta

Anon (1998): Model pengelolaan limpasan sedimen dan sampah Sungai Cifanduy (Laporan Akhir), Ditjen BANGDA dan Puspic UGM-BAKOSURTANAL, Yogyakarta

Anon (2001): Jawa Tengah dalam angka 2000, BPS Propinsi Jawa Tengah

Arifin, D dan Sarmili, L. (2000): Penyelidikan sebaran sedimen permukaan dasar laut di wilayah Pantai Segara Anakan, Kab. Cilacap, Jateng Departemen Pertambangan & Energi, Bandung

Bemmelen, R. W. Van. (1949): The geology of Indonesia Vol. I A, Martinus Nijhoff, The Hague

Datun, M. (1981) : Pengaruh arus terhadap arah sedimentasi di Segara Anakan Jawa Tengah, IAGI, Bandung

Ecology Team. (1984): Ecological aspects of Segara Anakan in relation to its future management, Institute of Hydraulic Engineering &

Faculty of Fisheries Bogor Agricultural University

Hadisumarno, S. (1964): Segara Anakan. Indonesian Geography Vol. 4-8

Hadisumarno, S. (1979): Coastal accretion in Segara Anakan Central Java Indonesia, Indonesian Geography Vol. 9-37

Hadisumarno, S, dkk. (1982): Remote sensing of geographical feature of the Cilacap region, Proceeding of The LIPI-UNU-UGM Workshop LIPI-UNU, Jakarta

Hamidjojo, P. (1982): The geomorfology of Segara Anakan area related to the tide and currents. Proceeding of The LIPI-UNU-UGM

Hardjosuwarno, S. (1982): Hutan mangrove Segara Anakan Cilacap suatu tinjauan keadaan sekarang dan perkembangannya pada masa mendatang, Baturaden

Hindaryoen (2001): Endapan lumpur mengubur, KOMPAS 24 –02-2001, Jakarta

Napitupulu, M and Ramu, K.L.V. (1982): Development of the Segara Anakan area of Central Java, Proceeding of The LIPI-UNU-UGM Workshop

Nelson, G, et, al. (1992): Land use change & sustainable development in the Segara Anakan area of Java, Indonesia–Relevan Information From Remote Sensing, Onground Survey And The ABC Method, Earth-Observation Laboratory of The ISTS Center Univ. of Waterloo and Gadjah Mada University

Ongkosongo, O.S.R, dkk. (1985): Keadaan lingkungan fisik Segara Anakan dan sekitarnya

PMO-SCADP (2000): Rapat koordinasi proyek konservasi & pembangunan Segara Anakan, PMO-SACDP, Baturaden

Rahardjo, W. (1982): Geological feature of the Cilacap region, Proceeding of The LIPI-UNU-UGM Workshop

Ratih, D.Taufik, M. (1998): Monitoring the changes of lagoon Segara Anakan, Central Java By using multitemporal Landsat data, Warta Inderaja Vol. X No. 1 MAPIN, Jakarta

Sutomo, H. (1982) :Tidal caracteristics and sedimentology of the Segara Anakan, Proceeding of The LIPI-UNU-UGM Workshop

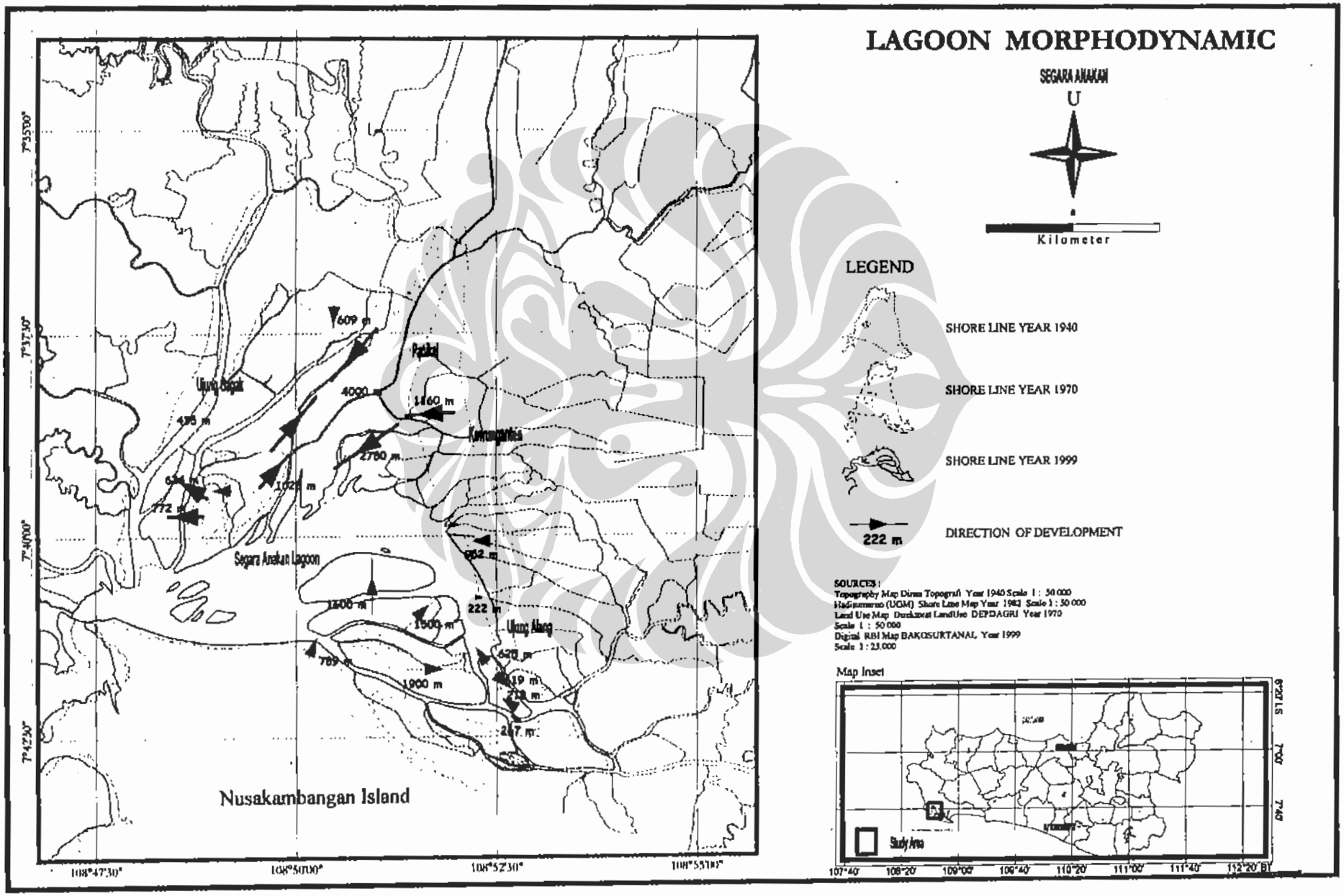
Uktolseya, H. (1984): Pola hidrodinamika lautan di daerah perairan Cilacap, Pertamina-PPTMG LEMIGAS

Wibowo, I.A. (1997): Keterkaitan kelimpahan makrozoobenthos dengan tipe substrat di perairan sekitar Pulau Tirang Malang Segara Anakan Nusa Kambangan Cilacap, Skripsi Fakultas Perikanan IPB

White, T.A, dkk. (1989): The coastal environmental profile of Segara Anakan-Cilacap, South Java, Indonesia, ASEAN/ US Coastal Resource Management Project/ICLARM, Manila

Map number 1

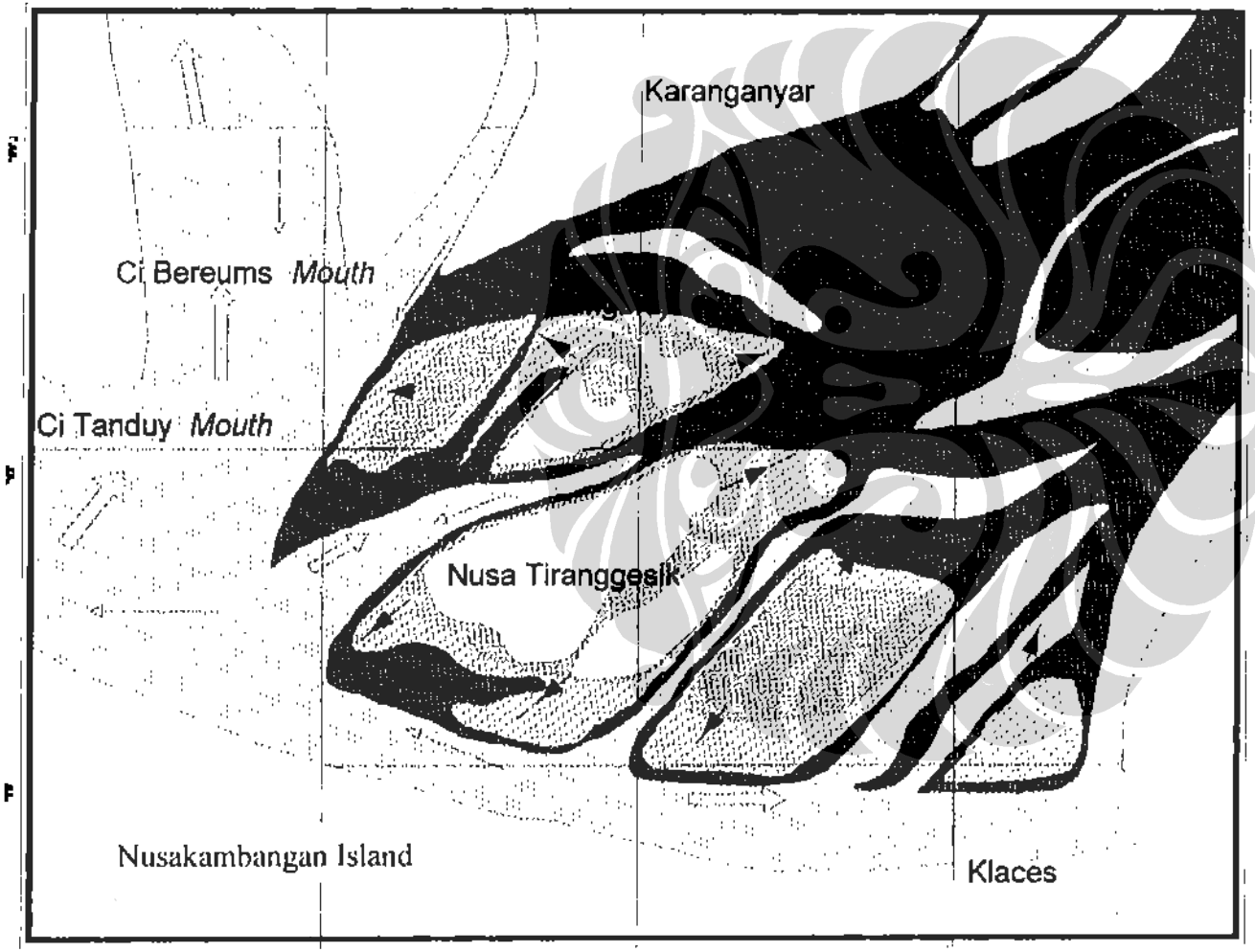
LAGOON MORPHODYNAMIC



SOURCES :
Topography Map Dinas Topografi Year 1940 Scale 1 : 50 000
Hadjamemo (UGM) Shore Line Map Year 1982 Scale 1 : 50 000
Land Use Map Dorkanet LandUse DEPDAGRI Year 1970
Scale 1 : 50 000
Digital RBI Map BAKOSURTANAL Year 1999
Scale 1 : 25.000

Map number 2

SEDIMENTATION PATTERN



SEGARA ANAKAN LAGOON

LEGEND

- LANDS
- REGION WITH LOW MUDDINESS
- REGION WITH ORDINARY MUDDINESS
- REGION WITH HIGH MUDDINESS
- REGION WITH NEW BARS
- BARS WITH MANGROVE
- BARS WITH GRASS POND AND OR RICE FIELD
- DIRECTION OF DEVELOPMENT
- FLOOD DIRECTION
- EBB DIRECTION

SOURCES
Identified from Aerial Photograph Years 1999
Scale 1 : 10.000

Map Inset