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Morphodynamics of Coastal Lagoons: An Analysis of Multitemporal Landsat Images of Segara Anakan Lagoon Area

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ABSTRACT

Lagoons are shallow coastal bodies of water separated from the ocean by a series of barrier islands which lie parallel to the shoreline. Sediment supplied to enclosed lagoons will influence the distribution and morphodynamics of coastal lagoons. Lagoons are re-shaped by erosion and deposition by the accumulation of material washed or blown over the enclosing barriers, and by the accretion of in-flowing river sediment. The purposes of this study is to describe the methodology and attain results for identification of multitemporal Landsat image data of the Segara Anakan Lagoon for the years 1978, 1994, 2003, and 2013. The method used in this study is a visual interpretation of Landsat by using GIS and remote sensing methods to produce maps of morphodynamics of a lagoon and multitemporal of a coastline change. The overall results for the identification of morphodynamics of coastal lagoons are the decrease of areas of water bodies, increase of areas of a land accretion, and coastline changes. The results are used to examine ecological management of coastal lagoons.

Keywords: Coastal Lagoon, Landsat Images, Morphodynamic, Multitemporal, Segara Anakan

INTRODUCTION

Environmental changes over the coastal areas are a result of regular processes that are continuous or periodically fluctuated such as oceanographic parameters and the dynamics of local climate. Coastal erosion, which is caused by the dominant factors of natural influence such as waves, currents, tides and sediment supply, leads to the changes of the coastline (Bird & Lewis, 2015).

The characteristics of these coastal zones are very dynamic (Woodroffe, 2002). There is an interaction between the land and sea through the role of the waves and winds. Erosion and sedimentation frequently occur in the coastal area, when rocks are eroded by the waves and winds. They will then deposit

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at such zones, which depends on the energy of the waves and winds. In such a place, it will change the form of a landscape (Davidson-Arnott, 2010).

By the time, these dynamic processes will generate a new landform or change an existing form of that place. In this term, coastal geomorphology focuses on explaining landform in the coastal zone by examining the shapes, sediment and depository history at the modern shoreline. It includes the study of shallow marine environment that is influenced by terrestrial factors and the land. The influence of the sea is also present and the long-term evolution of the coast is appropriately understandable (Woodroffe, 2002).

One of the coastal landforms that is influenced by natural processes and human activities is coastal lagoon. Even though its position is inland of water bodies, the lagoon is still affected by waves and winds from the sea. The lagoon environment is a closed and semi-closed environment formed by the interaction between marine and terrestrial processes, which has a complex resource that comes from the land and sea. Sources of water in the lagoon are the river and the sea, where tidal currents and waves still have the influence (Nichols & Boon, 1994). Additionally, coastal lagoon will be the depository place for sedimentation from the upland area (Magni et al., 2008). All human activities at the upstream, particularly agriculture and cultivation, bring soil, waste and other materials to the downstream area through the river.

Therefore, lagoon environment is very important to study. It is unique, not only because it has a variety of aspects (geomorphology, oceanography and climatology) but it also contains large mineral and biological resources (Zonta, Guerzoni, Pérez-Ruzafa, & de Jonge, 2007). Segara Anakan (SA), which is located in Indonesia, is an example of a coastal area which has a unique biophysical characteristic. The region has a great natural ability to ensure the sustainability of the interrelationships between terrestrial, estuarine and marine ecosystems in harmony and balance as a habitat for flora and fauna. The region is an area of migration of various types of protected animals and it is a place of breeding for diverse species of the shrimp and fish, which has a high economic value. Furthermore, the region is also a source of livelihood for the local community at large. Hence, it is reasonable for the government to consider the SA area as a natural resource, which needs to be conserved and as a capital base of regional development (Nandi, 2014).

Natural processes and human intervention on the environment of SA can cause ecological dynamics to occur. Therefore, monitoring the activities of the phenomenon needs to be done. One of the effective ways is through the application of remote sensing. The application of remote sensing technologies for monitoring environmental conditions may provide optimal results. Several studies have been conducted to show the effectiveness of the use of remote sensing for monitoring coastal lagoons (Baldock, Weir, & Hughes, 2008; Ardli & Wolff, 2009; Amos, Umgiesser, Tosi, & Townend, 2010; Duck & da Silva, 2012). Moreover, the use of remote sensing data can provide spatial analysis repetitively and continuously cover a relatively large area with a reasonable low-cost. In addition, it is also fast compared to terrestrial surveys. The data obtained from remote sensing can provide objective information, and the method is reliable and economical in the effort for inventory, monitoring and evaluation of resources (Klemas, 2011). Thus, in order to optimise the results of research, it can use multitemporal remote sensing data from Landsat MSS, TM and ETM (Alves, Venerando & Helenice, 2003).

The lagoon ecosystem of SA has experienced a severe environmental degradation due to the high rate of sedimentation and human activities in the forms of land uses that do not take into account sustainable development. The impacts of the human activities can clearly be seen from the number of mangrove forests in SA that have been converted into agricultural lands, settlements and aquaculture, which lead to increasingly depleted marine life (Jennerjahn & Yuwono, 2009). Moreover, abrasion and erosion are greater, and sedimentation is getting worse. As a result, it is now more difficult for the local communities to catch fish so that fish production is decreasing/declining. To make things worse, a reduced accumulation of water in the water reservoir above the estuary can cause flooding in downstream areas, which subsequently leads to multiplier effects such as damage of clean water, pollution of water resources, land degradation, as well as destructions of agricultural areas and community settlements.

Based on the above discussion, silting, environment degradation and possibility development of the lagoon's existence must be anticipated and addressed. Moreover, a suitable policy is needed to ensure that human activities can match the temporal and spatial dynamics of the coastal resources. More importantly, it is necessary to study in-depth concerning these complex issues. The study will focus on the analysis of multitemporal images by using Landsat data to explore the dynamic of SAL.

The investigation of morphodynamics of coastal lagoons made use of the GIS and remote sensing methods, which was intended by the interpretations of the multitemporal Landsat images produced by USGS-NASA. Basically, there are three data of Landsat images (MSS, TM, and ETM+) used for the analysis of ecological changes of the lagoon area. There are also several steps involved in producing the maps of morphodynamics and coastline changes (buffering and overlaying of maps).

The morphodynamics of coastal lagoons was obtained by assessing various Landsat images. The results show that there have been several changes in the morphology of the lagoon during the period of 1978-2013. This can be observed by the declining lagoon areas, which are caused by the sedimentation from surrounding rivers of that area of lagoon. The total area of the lagoon in 1978 was 4,665 hectares. In 1994, it decreased dramatically to 1758 hectares and the increasing of accreted land area was 219 hectares. From 1994-2003, the total area of the lagoon declined to approximately 767 hectares with the increased accreted land area of 258 hectares. In 2013, the total area of the lagoon was only 347 hectares, with a total area of 837 hectares of accreted land. Thus, within 35 years, the change of lagoon areas involved 4,318 hectares or a decrease of approximately 123.37 hectares/year, and the increased accreted land area of 22.5 hectares/year. The morphodynamics changes depend on factors such as the type of sediment, morphology and geology of the beaches (Stephenson & Brander, 2003).

MATERIALS AND METHODS

Multitemporal satellite images from USGS (Landsat MSS, TM, and ETM+) were used to obtain the necessary data for the years 1978, 1994, 2003 and 2013. Geological Map scale was 1:100.000, Topographical Map (*Rupa bumi*) scale 1:25.000, and ground truth. The results of satellite imagery interpretation include landform, land use and data. Geological map interpretation will generate data on main constituent material landform, while Topographical map generating slopes data through the interpretation of contour lines. Meanwhile, Ground truth was conducted with the location of points on the field based on a predetermined identification of landforms to make observations, measurements and interpretation of the matching results. Field check was performed to validate the results from the interpretation of imagery data and thematic maps that matched with the real condition. Besides, observations and data measurements that cannot be intercepted from the interpretation of imagery and thematic maps were conducted during the fields check.

Visual interpretation is intended to produce maps of morphodynamics of lagoons area and multitemporal land cover/use changes. Landforms of the lagoon maps are manually interpreted from the multitemporal Landsat imagery exposed with SRTM hill shade in the process. Recognition and identification of landforms from remotely sensed imagery was based on relief or shape, density and location. Then, to delineation the area of lagoon, it was derived from the images by digitising directly on screen or using digital elevation model (DEM). Manual digitisation on screen can help to determine the region of interest by making a polygon area, which distinguishes the surrounding region. Relief texture is very important to consider in interpretation.

Basic identification of landforms refers to the density that can be demonstrated by the appearance of which varies by utilising multispectral imagery. In this case, density becomes very important indication of relief through the identification of a shadow object. Location and landscape ecology in particular situations is an important part in the identification of landforms. It can be recognised from the structure or pattern of an appearance. Appearance characters of hydrology, vegetation, land use and the others are in a group, which can identify landforms easily. The location of those characters can be shown by the characteristics of the image through relief or density (Sulistyo, 2011).

The prior step before interpretation of landforms is drafting a colour composite image that will be used to perform manual interpretation of landforms. Once a composite colour image is compiled, the image enhancement is then performed, in this case using contrast-stretching techniques. It aims to improve the quality of the image so that it is easy to do interpretation manually.

RESULTS AND DISCUSSION

The Morphodynamics of a Coastal Lagoon

The morphodynamics of a coastal area involves the characteristics and time-series actions of coastal landforms and the trends controlling the actions within specific temporary and spatial data. A survey conducted on the morphodynamics of the lagoon's morphology has helped to understand the characteristic changes as a response to periodic and episodic activities resulting in changes in water courses, sedimentation transportation from watersheds, bathymetry and coastline alignment.

According to the multi-temporal Landsat data, it can be derived that there were serious morphological and coastline changes in the lagoons between 1978 and 2013 due to accretion and erosion. The accumulation occurred due to extreme sediment from the run-off in the

Citanduy and Segara Anakan watersheds and small tributaries surrounding the Segara Anakan Lagoon (SAL) area.

Changes to the lagoon's morphology (1978-2013)

Changes in the morphological of lagoons from 1978 to 2013 are presented in Figures 1-4, and the development of lagoon area is presented in Table 1.

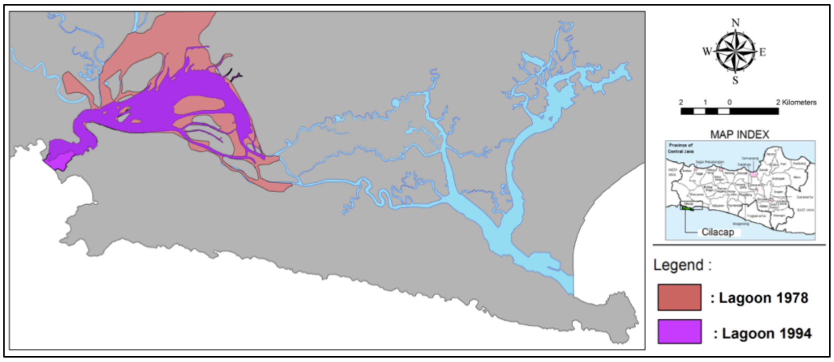

Figure 1. Changes to the lagoon's morphology (1978-1994)
(*Source:* MSS and TM images map, System coordinate WGS 1984 zone 49s; author's own results)

Figure 1 shows how the area of the lagoon changed from 1978 to 1994. This was a first phase of changing area at the lagoon. In 1978, the area of SAL was 4665 hectares, which was reduced dramatically to merely 1758 hectares in 1994. In other words, over 16 years, there was a loss of 2907 hectares. At that time, the first settlement was also built by farmer immigrants from the main land such as Java and Sumatera islands (Ardli & Wolff, 2009). Moreover, during that time, the area of accretion also increased significantly due to sedimentation transport from the upland watersheds. The area of land accretion in 1978 was 49 hectares, which increased by 170 hectares in 1994 to 219 hectares. This means that the increase in land accretions per year over that period was approximately 10.63 ha.

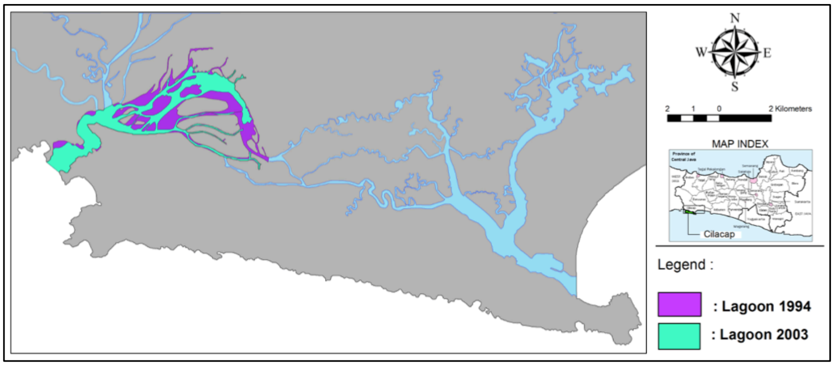

Figure 2. Changes to the lagoon's morphology (1994-2003)
(*Source:* TM and ETM images map, system coordinate WGS 1984 zone 49s; author's own results)

Figure 2 shows changes in the lagoon morphology from 1994 to 2003. The area of SAL did not only change in 1994, but also in 2003, with additional land accretion of approximately 39 hectares. The total area of SAL in 2003 was 991 hectares, which means that over a period of nine years, another 767 hectares were lost from the lagoon. The main cause is the high rate of sedimentation of the Citanduy River, which carries more than 9 million tons m^3 per year of sedimentation matter. Over this same period, an additional resettlement complex has also more than 2000 ha established. This further accelerated the process of environmental degradation in SA. Not only settled but also they stated the management of rice farming, which was running quite successful with the technical assistance provided by community organisation.

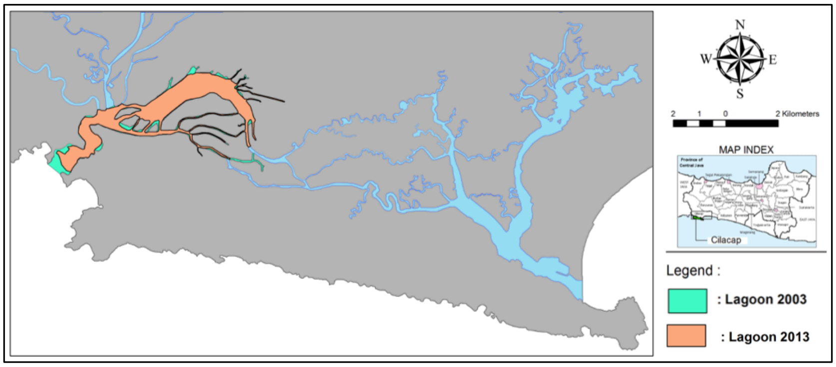

Figure 3. Changes to the lagoon's morphology (2003-2013)
(*Source:* ETM and Landsat 8 images map, System coordinate WGS 1984 zone 49s; author's own results)

Likewise, Figure 3 shows the changes to the lagoon's morphology from 2003 to 2013. In 2013, the SA area was reduced from 644 hectares to 347 only hectares, with additional 579 hectares of accreted land, reflecting that over ten years, the lagoon became narrow with an increase in the accreted land of 57.9 ha/year. It was clear that the extensive lagoon would diminish with a tendency to disappear in the coming year, covered by the sediment. However, the main factor has also increased at that time, i.e. illegal logging of mangrove in this region (Jennerjahn & Yuwono, 2009).

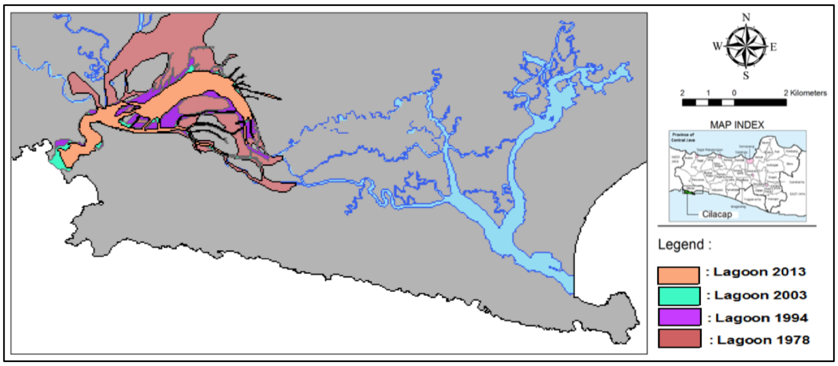

Figure 4. Changes to the lagoon's morphology (1978-2013)
(*Source:* MSS, TM, ETM and Landsat 8 images map, System coordinate WGS 1984 zone 49s; author's own results)

Figure 4 shows the overall changes of the lagoon due to sedimentation and accretion. From 1973 (the first phase of changes), the lagoon area was still in natural condition, i.e. there was not disturbing factor that caused area of the lagoon to shrink. In the second phase (1994), the area of lagoon tended to decrease as an effect of natural phenomenon such as the eruption of Galunggung Mountain volcanic in 1982.

Table 1
The development of the SAL area over the period 1978 – 2013 (Source: Author's own results, 2015)

Years	Lagoon Area (Ha)	Decrease (Ha)	Accreted Land (Ha)	Increase (Ha)
1978	4665	-	49	-
1994	1758	2907	219	170
2003	991	767	258	39
2013	347	644	837	579

Figure 5 shows the shrinkage of the water area in SAL. It can be seen that those changes from the emergence of new land or an increase in the extent of land that had previously been in the lagoon, as well as a reduction in the water area of the SAL.

The shrinkage of the water area of SAL can be seen in Figure 6, which shows that the emergence of land accretions occurred in the middle, western and northern parts of the lagoon. The shrinkage of the water area of SAL is strongly associated with the occurrence of erosion and sedimentation.

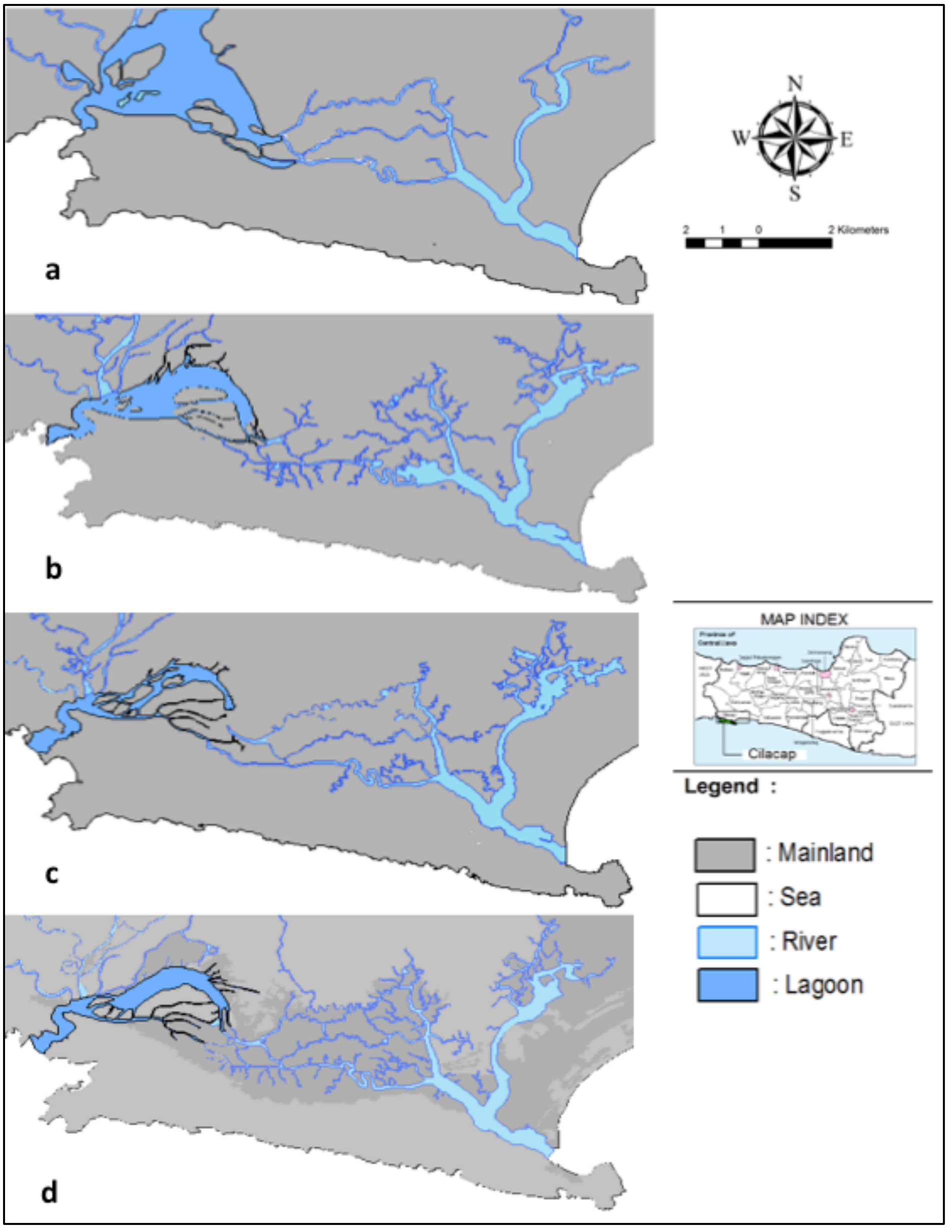

Figure 5. Changes to Segara Anakan lagoon's morphodynamics since 1978 (a-d)
(*Source:* MSS, TM, ETM and Landsat 8 images map, System coordinate WGS 1984 zone 49s; author's own results)

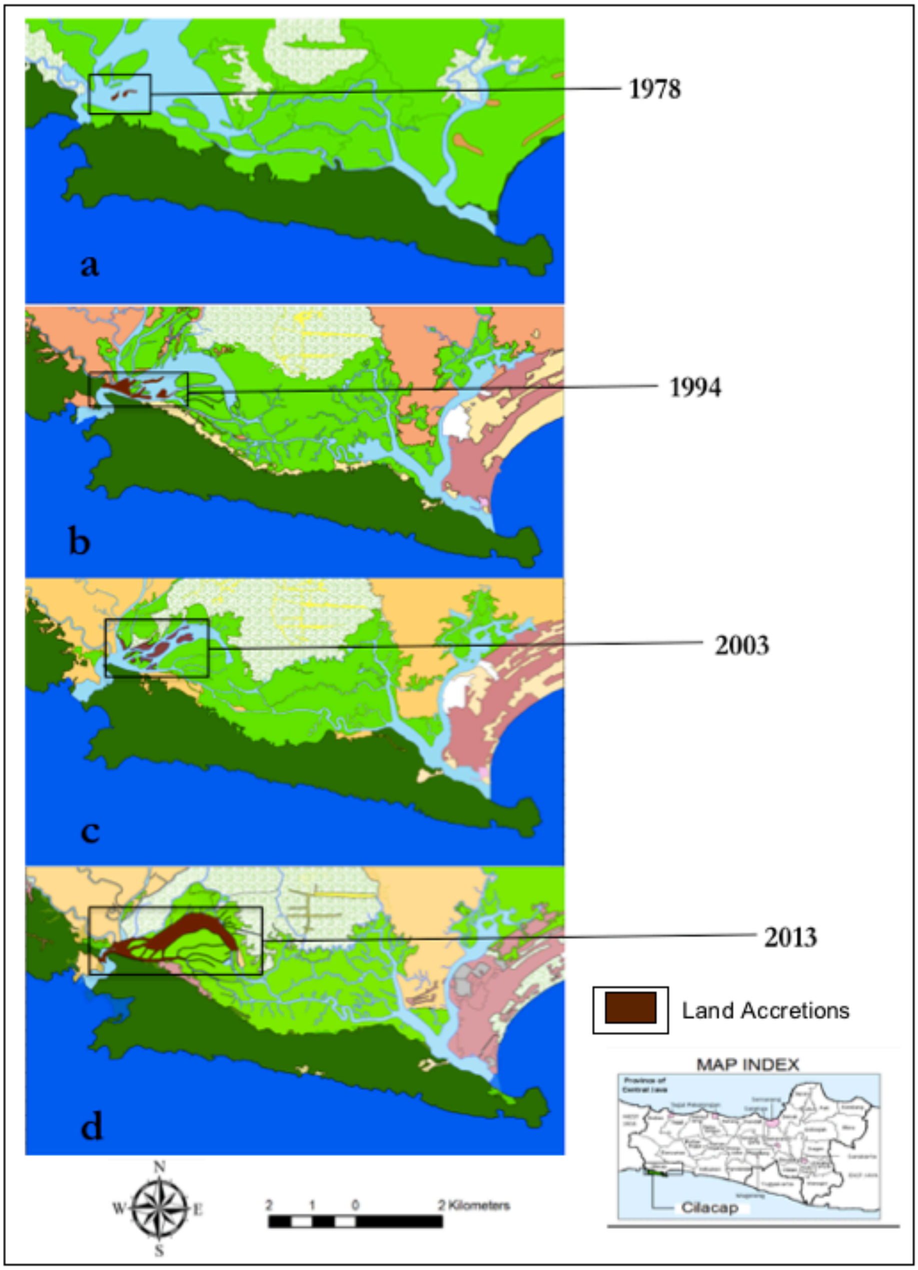

Figure 6. The development of land accretions in the Segara Anakan Lagoon since 1978 (a-d) (*Source:* MSS, TM, ETM and Landsat 8 images map, system coordinates WGS 1984 zone 49s; author's own results)

Figure 7. Sedimentation matter brought from Citanduy River

Figure 7 shows that the materials deposited into the SAL consisted of clay, silt and sand. Sediment from Citanduy River contributed to more or less 9,000,000 tons m^3/year. Citanduy River located in Western Java, where it flows through two provinces of West Java and East Jawa through Ciamis Regency and Cilacap Regency.

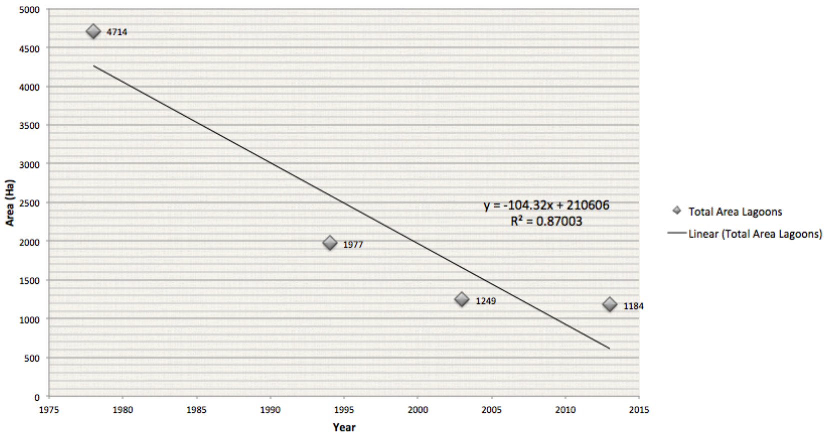

Figure 8. The formula used for the linear regression of the total area of Segara Anakan Lagoon, 1978-2013 (*Source:* Author's own results, 2015)

Figure 8 is the formula used for the linear regression of the total area of Segara Anakan Lagoon in 1978-2013. It shows how much of a change there is between the beginning of the trendline and the end. Regression lines also give us useful information about the data they were collected from. They show how one variable changes on average with another. For instance, the trends of the area drecreased during the development of lagoon, but on the other hands, the area of land accretion was significantly increased.

In addition to the reduction in the area of water found in the SAL, there has also been an additional area of land accretion as shown in Figure 6, which illustrates the extent of the area from land accretion in 1978 (Part a). Meanwhile, Part b shows the changes to the area of the SAL and the increase in the area for land accretion in 1994. Likewise, parts c and d show the changes in the land accretion area in 2003 and 2013. Hence, over a 35-year period, there has been an increase in the area of land accretion, covering 788 hectares, with the growth of land accretion at approximately 22.5 ha/year as a result of sedimentation.

Coastline Changes (1978-2013)

Sedimentation from the soil resulted in legal land tenure. In contrast, damages to coastal areas, due to abrasion in areas that are less stable against water erosion, caused a critical state of the land, damaging road infrastructure.

Besides the effects of sedimentation processes that were taking place in the SA water body, the abrasion process also influenced morphological changes to the SAL. The abrasion process taking place had impacts on the shape and coastline in the western part of the SAL (The comparison of coastline changes from 1978 to 2013 can be seen in Figure 9).

Coastline changes were analysed from Landsat images from 1978, 1994, 2003, and 2013. Coastline extraction from the Landsat images was processed based on the composites from band 543. To record coastline changes, multitemporal coastlines were overlapped. These changes were then used to determine where accretion and abrasion had taken place.

The area under investigation was limited to the shoreline of the SAL. It was divided into three profile areas: A, B, and C. Each profile area was representative for a particular coastline area, i.e. A for the West Channel (*Palawangan Barat*), B for *Nusakambangan Island*, and C for the East Channel (*Palawangan Timur*).

Based on the geomorphology of those area, the coastal area of Cilacap is a coastal region with an average height of less than 2 m. With alluvial soil types and textures of sandy, it is possible that the coastline changes from southern to the northern coastal area of Cilacap with an average rate of shoreline change of 60 m per year in the past 10 years.

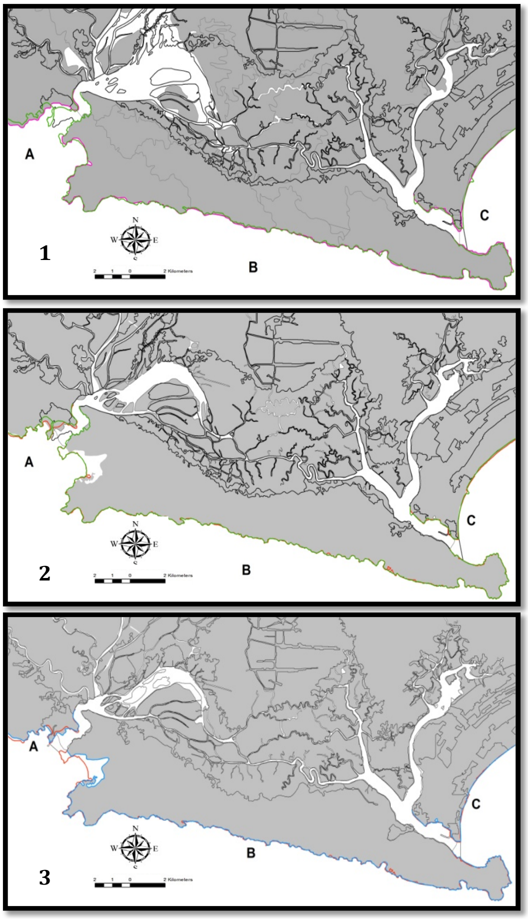

Figure 9. Coastline Changes from 1978-2013: (A) West channel, (B) Nusakambangan, and (C) East Channel (*Source:* MSS, TM, ETM and Landsat 8 images map, system coordinates WGS 1984 zone 49s; author's own results)

Table 2
Area (Ha) of sedimentation changes in the SAL (Source: Author's own results, 2015)

Zone	Change in area (hectares) 1978 – 1994	Change in area (hectares) 1994 - 2003	Change in area (hectares) 2003 - 2103
A (West Channel)	14.19	2.95	0.83
B (Nusakambangan)	0.95	0.47	0.79
C (East Channel)	1.64	1.41	0.37

In the meantime, sedimentation processes have also started to occur in the West Channel. They have changed the mouth of the lagoon. Table 2 shows that the area of this change was approximately 14.9 hectares over the period of 1978 - 1994, 2.95 hectares (1994-2003), and

0.83 hectares (2003-2013), respectively. Hence, the total area of sedimentation from 1978 to 2013 was 18.68 hectares (see Table 3), with the distance from the coastline to the mainland (zone A) changing from 1.4 km over the period 1978-1994, 32 m in (1994-2003) and 88 m in 2003-2013. Hence, the total change in the distance from the sea to the mainland was 1.5 km.

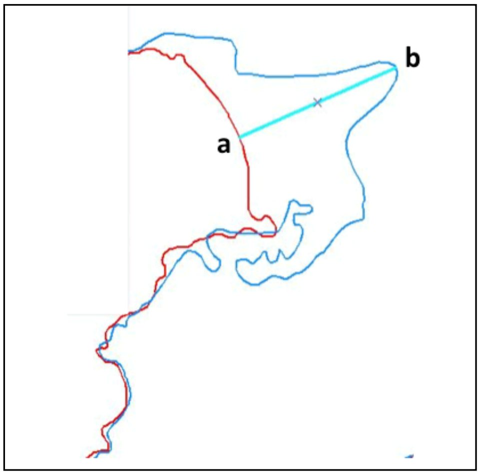

Figure 10. Coastlines changes 1978-2013 in the West Channel (A) sample area
(*Source:* Author's own results, 2014; afer MSS, TM, ETM and Landsat 8 images map, System coordinates WGS 1984 zone 49s)

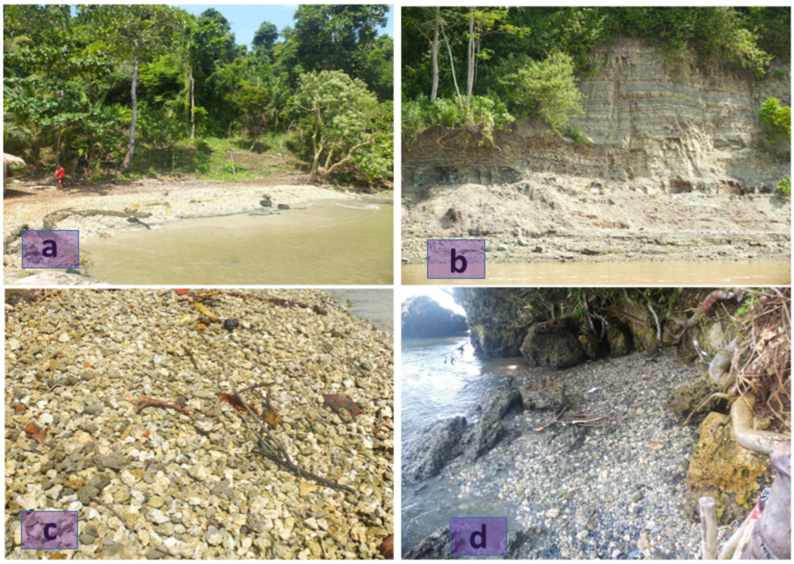

Figure 11. Geomorphological processes in Segara Anakan Lagoon
(*Photo:* Author's, 2013)

Figure 11 shows the abrasion, erosion, and deposition processes in the area of investigation. Based on the observation and analysis of type of rocks, it could be described that: (a) Alluvial plains, found on the northern coast; (b) Erosion in the river valleys in the southern part of Nusa Kambangan Island, which consists of mud, sand, gravel and clay results deposition of broken breccia stone; (c-d). Deposition of limestone and marl in the Northern and Southern Coast of Segara Anakan.

Morphodynamics and Implications

SA is a lagoon located in Cilacap in the Central Java Province. SAL has a very important function as an estuary for rivers such as Citanduy Cibereum, Palindukan, Cikonde, and other small tributaries. SAL was once a lagoon with a unique ecosystem consisting of the water body (the lagoon), which is brackish, mangrove forests, and the lowlands that are tidally influenced. For this reason, the lagoon ecosystem of SA has naturally served as a spawning ground for shrimp and fish, as well as a habitat for migrant and non-migrant water birds, various types of reptiles and mammals, and different species of flora. However, the lagoon ecosystem of SA has recently experienced severe environmental degradation caused by the high rates of river sedimentation and human activities in the form of land uses that do not take into account sustainable development.

The classification of multitemporal remote sensing images has been presented. Such an approach allows the classification of a remote-sensing image acquired for a specific geographical area at a given time, in the cases where training data are not available. The classification is performed using the statistical parameters estimated for an image acquired in the same area before the one under analysis. In this case, the results of the classification for morphodynamics and land use by the Landsat interpretation were used to analyse the spatial problems of the SAL area.

The Multitemporal analysis of the morphology and land use changes using remote sensing data is a method of analysis that is both effective and efficient (Klemas, 2011). With this analysis-based method, the multitemporal remote sensing of multitemporal images with a medium spatial resolution was used to derive information on landforms, land cover or land use. The details derived from the information can be tailored to the characteristics of the ability of the remote-sensing image data and standardised information needs and objectives, as well as the level of analysis to be performed and determined by the method of analysis used. In this study, the overall accuracy of the results was found to be 85 to 96% for the thematic accuracy of the results and interpretation of the lagoon's landform classification at a spatial resolution of 30 m.

SAL is a product of tectonic activities taking place within the depression zone. The formation of the SA waters took place because it is on the lower part below sea level. SA was formed from dikes and rocks composed essentially of sandstone from Tapak formation, from the upper Miocene - Pliocene. The conditions of the landscape of this area take on the form of the Southern-Mountains, including Nusa Kambangan, Jampang Formation, Pamali Formation, and Pamutuan Formation. These three formations are much older than the Oligo-Miocene period, as can be seen from the bedrock that is far below Tapak Formation.

The morphological condition of the lagoon changes in line with time and processes occurring within the area. From the data processing and results obtained, the water areas of SAL are shrinking from year to year. The shrinkage indicator of the water area of SAL can be seen from the emergence of new land or an increase in the extent of land that had previously been in the lagoon, as well as a reduced water area of SAL. Every year Citanduy, Cimeneng and Cikonde Rivers carried 5 million m^3 and 770,000 m^3 of sediment, of which 740,000 m^3 and 260,000 m^3 were deposited in SA, resulting in increased siltation of new land area in the waters of the lagoon. Thus, these conditions did not only affect natural communities and habitats, but also the culture of the people of Kampung Laut. For example, fishermen used to build their houses on stilts above the sea, but most of them now build brick houses on the mainland.

Based on the morphological comparisons of SAL from the Landsat image interpretations in 1978, 1994, 2003, and 2013 (see Figure 5 and Table 1), it can be clearly seen that the morphological changes of the lagoon have occurred in the western part of the lagoon. The area of the lagoon narrowed due to intensive sedimentation from the river Citanduy that will eventually create a lagoon in the future.

Extensive lagoon narrowing can also cause a reduction in the area of mangrove forests. Because of the equally important elements of lagoon in maintaining biodiversity and marine life, its presence must therefore be conserved and preserved. One solution to overcome this problem is to divert the course of the river Citanduy, which minimises the number of streams carrying sediment directly into the Indian Ocean. However, this method is also controversial as it results in other areas being affected by the rate of sedimentation. In addition, sediment dredging has been carried out in a very shallow area. Dredging is done so that the flow of tide will enter the lagoon because SAL is also influenced by the tides of the Indian Ocean through the western and eastern channels.

Sedimentation causes a variety of problems such as the declines in fishermen's incomes, conversion of mangroves into agricultural land, emergence of conflicts of interest between the local community and the Forest Agency regarding the use of land accretion, and the threat to SA from offshore fishing. Accreted land also causes disputes between those who want to keep it as a forest and the local government who wants to convert it for cultivation. At the rate of land accretion at approximately 22.5 ha/year due to sedimentation, this creates a high potential for conflict.

Sedimentation from the soil resulted in legal land tenure. In contrast, damages to the coastal areas due to abrasion in areas that are less stable against water erosion caused a critical state of the land, damaging road infrastructure. The process of coastal erosion (abrasion) in the western part of SA lasted quite a while, so the shoreline has basically retreated quite far away from the old shoreline mainland, which at this time is approximately 2 km from the edge of the sea. The coastline generally changes from time to time according to the changes in natural activities such as that of the waves, wind, tides and currents and river delta sedimentation area.

Inland and coastal sediments are essentially dynamic, moving according to the dimensions of space and time. Breaking waves, tidal streams, rivers, coastal vegetation and human activities are the factors that cause changes to the dynamics of the coast to establish a new equilibrium beach. Not every coastal area can respond to the whole process of changes, depending on several factors such as the type of sediment, as well as morphology and the geology of the beaches (Stephenson & Brander, 2003).

Symptoms of shoreline change need urgent attention, given the major impacts on social life and the environment in order to realistically determine the likelihood of land use changes of the coastal areas of SA. Shoreline changes on the whole have changed from time to time in line with the changes in natural activities such as that of waves, wind, tides and currents and river delta sedimentation area (Davies, 2011).

Shoreline changes also occur due to the interferences to coastal ecosystems such as the construction of dikes and canals, as well as the buildings that surround the beach. Coastal mangrove forests, as a buffer function, have been greatly revamped to serve as the regional farms, residential and reclaimed areas that result in changes in the coastline. The development of the coastline, based on the pattern of sedimentation on the West Coast of SA, is likely to cause the formation of a bay.

CONCLUSION

The multitemporal satellite image can be used to evaluate the morphodynamic of the SAL area. The morphodynamics of coastal lagoons was obtained by assessing various Landsat images. During the period of 1978-2013, there were several changes in the morphology of the lagoon. These could be observed by the declining lagoon areas, which is caused by the sedimentation from Citanduy, Cimeneng, and Cibeureum Rivers, as well as other tributaries surrounding the SAL area. The coastline changes during 1978 – 2013 were due to the processes of erosion and sedimentation alternated within a relatively close distance and were parts of the dynamics of the beach. The total change of distance from sea to the mainland was 1.5 km. Coastline changes occurred in the western part of the lagoon are due to the currents and waves that enter the western channel of SAL, which is being greatly restrained by an accumulation of the sedimentation in the western part of the lagoon. Thus, the Indian Ocean tidal waves veer towards the edge of the mouth of the lagoon, while a deposited area has also been formed surrounding the mouth of the lagoon with the total area of 18.68 hectares of sedimentation from 1978 to 2013.

Resource degradation is expressed by the emergence of the lagoon's ecosystem damage. Seasonal factors such as the emergence of oceanographically characteristics also become the factors that accelerate sedimentation. In addition, the soluble waste that empties into the lagoon system also influences the lagoons ecosystem damage. Consequently, synergic coordination measures between upstream and downstream regions are necessary in the future.

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